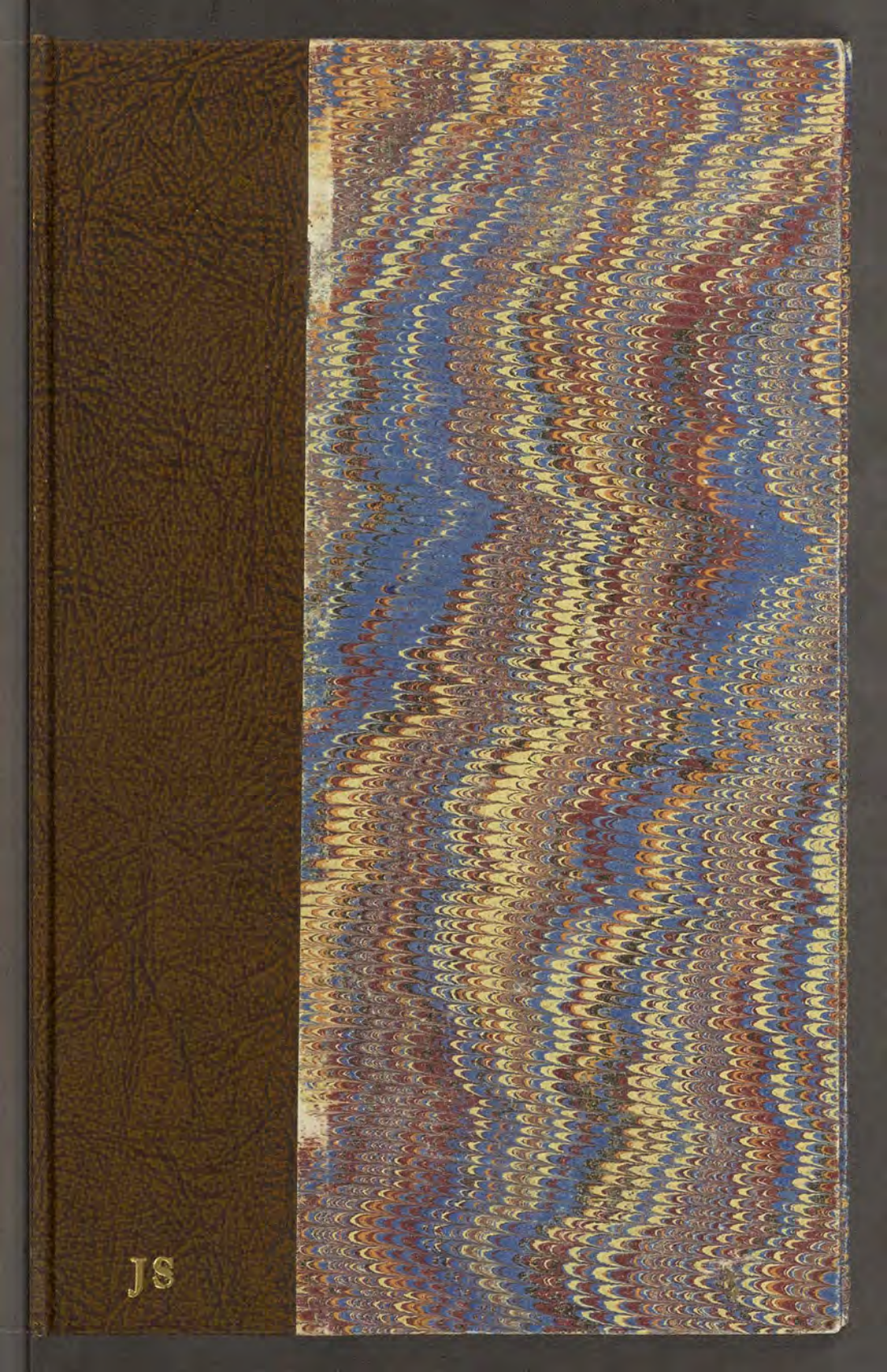
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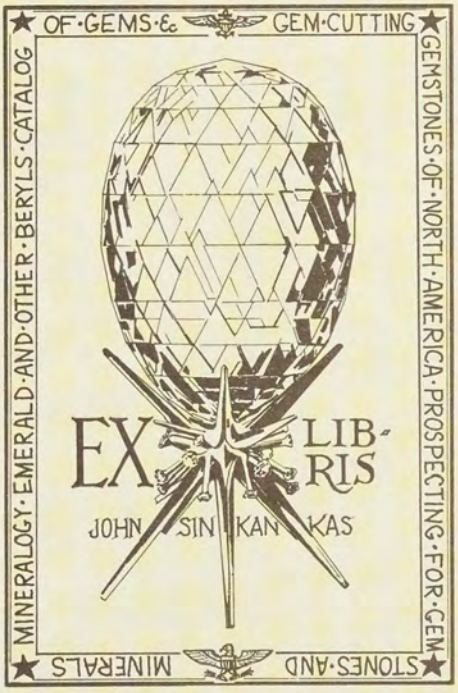

Extracted from T. Bergman's Physical and Chemical Essays, translated by Cullen, London, 1784, volume 3, pp. 205-316.

THOUGHTS

ON A

NATURAL SYSTEM

OF

FOSSILS.

Res ardua, vetuſtis novitatem dare, novis auctoritatem——dubiis fidem, omnibus vero naturam et naturæ ſuæ omnia.

PLINIUS.

PART I.

ARRANGEMENT OF FOSSILS.

NATURAL BODIES IN GENERAL.

§ 1. *Principal Diviſion of Natural Bodies.*

ALL bodies which nature ſpontaneouſly produces upon the ſurface of the earth may be properly divided into *organiſed* and *unorganiſed.*

§ II. *Organiſed*

§ II. *Organiſed Bodies.*

THESE are poſſeſſed of a number of internal veſſels, by which, from the nouriſhment they take in, the particles neceſſary to the increaſe, ſupport, and propagation of ſuch bodies, are extracted, prepared, conveyed, and diſtributed.

§ III. *Claſſes of organiſed Bodies.*

THESE bodies are diſtinguiſhed by the epithet *living;* and, whether they poſſeſs ſenſibility or not, they conſtitute two immenſe claſſes, the *animal* and the *vegetable*, which are commonly conſidered as two diſtinct kingdoms in nature.

§ IV. *Unorganiſed Bodies.*

THOSE bodies are termed unorganiſed that are entirely without any organic ſtructure, and ſeem to be formed by the accumulation of particles united ſolely by the external force of attraction.

§ V. *Various*

§ v. *Various Conſiſtencies of unorganiſed Bodies.*

THESE differ in many reſpects, but we ſhall here take notice of the degrees of *denſity* only, which has commonly been deſigned by the name of conſiſtence.

§ VI. *Solid Bodies.*

CONSIDERING theſe, then, according to this rule, we find ſome bodies ſo *ſolid*, that their particles are ſo firmly united as not to be ſeparated but by a very conſiderable force. Of this kind are moſt of the foſſils.

§ VII. *Liquid Bodies.*

SOME again are *liquid*, whoſe component parts adhere ſo looſely, that they may be ſeparated by the ſmalleſt impulſe; but being left undiſturbed, they, by the force of gravity, arrange themſelves in ſuch mutual equilibrium, as to preſent a ſurface parallel always to the horizon.

§ VIII. *Fluid*

§ VIII. *Fluid Bodies.*

OTHER bodies are reckoned *fluid*, whoſe particles are not only eaſily ſeparable, but ſeem in ſome degree to repel each other. It is true, they ſeek an equilibrium; but, as they are not leſs influenced by elaſticity than by gravity, they oftener appear with the unequal ſurfaces we daily ſee in clouds and vapours.

§ IX. *The Utility of this Diſtinction.*

ALTHOUGH the ſame body, as occaſion requires, may undergo every variation of conſiſtence, yet this diſtinction is not the leſs to be regarded; for peculiar qualities, with a conſiderable difference in their proportions belong to each condition. But the plan we have propoſed to follow, will not admit of a further explication of this matter.

§ X. *The continued Series of Natural Bodies.*

THE great Leibnitz, by that law to which he gave the name of *continuity*, denied formerly that there could poſſibly be any interruption between

tween physical causes and effects; and maintained, with such confidence, its invariable operation and influence, that he predicted, that some time or other a species of animals (as the zoophyta) would be discovered, partaking more or less of the nature of vegetables.—The celebrated Trembleyus, by the discovery of the Polypi, afterwards confirmed the truth of this presage. Daily experience also convinces us of the existence of such a connecting chain in the order of natural bodies; so that, though we are acquainted with several links singly, yet it may seem scarce possible to ascertain those that should be immediately united to them.

§ XI. *The Necessity of a System in Natural History.*

As natural bodies may in various ways be rendered useful to man, a thorough knowledge of them becomes highly necessary; and it will, indeed, in general be found, that their utility encreases in proportion to the extent of that knowledge. Their great number and variety require systematic arrangement; without which the necessary distinctions could not be made, and which, in some cases, where the difference is very minute, would be productive of great inconvenience.

§ XII. *Criteria of Natural Bodies.*

In order to diſcriminate with ſafety and preciſion, even where bodies are united in the greateſt affinity, it is an object of the firſt importance to eſtabliſh proper *criteria*.

§ XIII. *Conſtant and perpetual Forms of Organic Bodies.*

In the egg, or in a fecundated germ, the little body, the rudiment of the future fœtus, lies wholly concealed, until by proper heat and nouriſhment it is gradually evolved, increaſes, and arrives at maturity. In all organic bodies, therefore, the form is predetermined from their very origin, which the power of their internal and peculiar ſtructure is calculated to develope; ſo that between theſe two qualities the relation is invariable; and therefore criteria are not improperly collected from that external figure which is derived from, and rooted in the eſſential character of the ſpecies.

§ XIV. *Monſtrous Productions.*

Among theſe, indeed, we ſometimes find deviations from the general laws of nature, producing *monſters*; but ſuch events which are rare, and

and ariſing from particular cauſes, are almoſt always unlike each other.

§ xv. *Foſſils.*

All unorganic bodies, as well ſolid as liquid, which are either altogether without any organic ſtructure, or diſplay the ruins only of organization, are denominated *foſſils*, or more commonly *minerals*.

§ xvi. *The Mineral Kingdom.*

The term *foſſil*, or *mineral kingdom*, is generally applied to an arrangement of ſuch foſſils as are found in the earth.

§ xvii. *Generation of Foſſils.*

In this third kingdom of nature, the proceſs of generation is carried on in a manner widely different from that of organized bodies. Here is no egg, no ſeed, to cheriſh and ſupport the future foſſil, confined and reſtrained within the narroweſt limits; no fecundation; no eſtabliſhed circulation of the nouriſhing fluids; nor any evolution. Molecules uniting, by the ſole

power of attraction, form at once the growth and perfection of foſſils.

§ XVIII. *Variable and inconſtant Form of Foſſils.*

FORM, and other external qualities, of which the ſenſes only can determine, depend upon circumſtances that are perpetually varying, but which do not in the leaſt affect the intrinſic nature of the foſſil.

The poſition may poſſibly need the illuſtration of an example. Let us take a quantity of water, charged with aerated calcareous particles, and we ſhall ſee ariſe various figures, textures, and coheſions, according to the different modes in which the concretion was performed. By the ſubſidence only of the atoms a cruſt is generated, parallel to the bottom, if the diſtribution of them has been made equally throughout the whole maſs; if otherwiſe, the greater part forms tubercles farther from the ſurface of the bottom, than in the ſuppoſition of equality. Water impregnated with aerial acid acts like a menſtruum; and, though it does not at all affect the ſaturated particles in this hypotheſis, yet it nevertheleſs has conſiderable influence in forming their concretions. Such water oozing through ſubterraneous vaults, generates calcareous drops, hanging from the roof, while pointed

pointed cones are produced by the falling fluid upon the floor, and both increaſing in length, meet at laſt, and form one continued column.—If the ſame water purſues its trickling courſe along the walls, we find them covered with a ſtalagmitic cruſt; which according to the diverſity of the protuberances exhibits a great variety of figures, that, with the aſſiſtance of a warm imagination, may be made to reſemble complete animals, or their ſeveral members, and a thouſand other forms and appearances.—From this water ſuffered to remain long at reſt, ſpataceous cryſtals are ſeparated, that aſſume various ſhapes; as the granatic, the ſchoerlaceous, hyacinthic, dodecaedric, and thoſe pyramidal on both ſides, named ſwines teeth,—and many others.

The internal texture likewiſe admits of conſiderable variation. The moſt ſubtle particles unite into a denſe and equal maſs: Thoſe that are granulous, and of many angles, form combinations more rough and uneven; ſuch as are produced by chryſtallization appear ſpataceous; and others that are alternately depoſited in ſtrata, or lamellæ, preſent a divided ſtructure.

The degrees of coheſion alſo vary according to circumſtances. Water charged with fine particles of aerated chalk, and quickly evaporated, leaves a powder ſcarcely cohering, and which ſoils the fingers, like the mineral known

by the name of Agaric. Larger maſſes however of calcareous powder, expoſed for many years to the preſſure of a conſiderable weight, acquire at length ſuch a degree of conſiſtence, that diſtinct lines can be drawn with ſmall pieces of them; indeed this property is found in calcareous chalk likewiſe.—Hitherto the greater degree of hardneſs has been produced by cryſtallization, as we find that calcareous cryſtals make no mark whatever, a circumſtance owing to the firm union of their particles, by which the friction on a painter's canvaſs has no effect upon them, at leaſt ſo as to be viſible.

What has been thus briefly ſtated may be ſufficient to ſatisfy us, that, from the external qualities of foſſils, no proper judgement can be formed of their internal compoſition.

Of the several Criteria of Fossils.

§ xix. *Oryctology.*

Oryctology, or Mineralogy, are names given to that ſcience, which ſo arranges all the known foſſils, that they may be accurately diſtinguiſhed from each other.

§ xx. *Various*

§ XX. *Various Syſtems of Oryctology.*

As zoologiſts, in their arrangement of animals, have choſen different parts; ſome the feet, others the teeth, the becks, and other parts, according to the agreement or diſagreement of which their different ſyſtems were eſtabliſhed; and, as botaniſts have differed in the principles of their ſcience, one preferring a leaf, another the petals, a third the ſtamina and peſtillum, while a fourth maintains the ſuperiority of the fruit;—even ſo is it with mineralogiſts, who have often purſued very different paths, in their endeavour to illuſtrate and confirm the ſame object. Such a view of natural bodies, taken as it were from many different points, has however its advantages, as it increaſes the number of accurate compariſons. But, as every method cannot equally anſwer the end propoſed, it becomes neceſſary to ſelect that which is the moſt perfect and convenient.

§ XXI. *The beſt Arrangement.*

As, in order to underſtand the nature of foſſils, and apply them to purpoſes of utility, it is neceſſary to arrange them in ſome kind of ſyſtematic order, the preference is certainly due to that method, by which both their internal cha-

racter and compoſition may be made equally evident. Eſſential properties depend on the quality of the parts that enter into compoſition, and their mutual proportion; and, unleſs we are well aquainted with theſe parts, we ſhall labour to little purpoſe, in our attempts to mould them to our own deſires: Nay, we often meet with diſappointments, becauſe we have not conſidered that our views are inconſiſtent with the very nature of the materials ſubjected to experiments.

§ XXII. *In what manner the Compoſition of Foſſils may be aſcertained.*

HAVING ſettled theſe points, it remains yet to be determined in what manner we are to judge of the *compoſition* of foſſils: Whether the connexion between ſuperficial marks, and the intrinſic character, is ſo intimate and conſequent, that the former cannot be known, without the other being revealed? whether it may be neceſſary to proceed by a chemical analyſis in the dry way? or, ſhould this not be ſufficient, are we to have recourſe to the moiſt way? We will conſider theſe queſtions ſeparately.

§ XXIII. *External Criteria.*

IF, through the means of criteria collected from

from the external appearance, and obvious to all, we were able to obtain the object of our research, no method could certainly be more simple; for, with the assistance of our senses only, we might dispense with the tedious processes of experiments: But we have already discovered the fallacy of relying on many of these marks, even the most principal, as they are liable to be affected by various circumstances of situation, and diversified without end, (§ xviii.). It may be proper, therefore, to enter a little more minutely into the consideration of this question.

§ XXIV. *Uncertain and deceitful Size of Fossils.*

In no criteria can we possibly have less faith than in that of magnitude; and we cannot sufficiently express our astonishment at the violence offered to nature, when a larger piece of stone, referred to its proper genus, if reduced to a powde, is not only exiled to some other, but is not even permitted to remain under the same class.

§ XXV. *And Colour.*

The vulgar proverb, that cautions us against belief in colour, is not inapplicable to oryctology. It is well known, that there are seven primitive colours; and, in order that a body appear coloured, it is requisite that some particular

cular kinds of rays be reflected; would we enquire into the cauſe of this phenomenon, we muſt ſeek it in the quality of the ſurface, which is indeed often ſo tranſient, that the colour may be changed, or entirely deſtroyed by the heat of boiling water, or even by the influence of ſolar light.

A tranſparent colour ariſes from tranſmitted rays, and ſeems to indicate a ſpecies of attraction; while, on the other hand, an opaque colour implies repulſion. Both without doubt ſuggeſt the idea of ſome relation between the light and the given body; but which is of ſuch ſubtlety, that though it alone were varied, the character of the matter remains altogether unaltered; at leaſt the difference is not obvious to the ſenſes. We have ſeen, that tranſparency depends upon the diſpoſition of the particles; and this once diſturbed, the tranſparency vaniſhes, and with it all the effect produced by tranſmitted rays. Theſe ſeveral appearances ſeem to ariſe from the phlogiſtic molecules, which vary either as to quantity, magnitude, or elaſticity. Velocity even determines the difference of colours.

§ XXVI. *Internal Texture and Form.*

We have already touched on *internal texture and form* in the foregoing diviſions, (§ xviii.)

Determinate

Determinate figures bear a reſemblance to geometric bodies, and it is not without ſome degree of probability that they are ſaid to be derived from the nature of the matter: An opinion that has long influenced many to believe, that certain figures were proper and eſſential to different ſubſtances. The folly of this doctrine I have elſewhere demonſtrated at large *. If therefore regular figures, and thoſe beſt defined, are fallacious, we are ſurely not to rely on any ſuperficial characters which are very often common to ſubſtances of the moſt oppoſite qualities, and never uniformly conſtant in the ſame ſpecies.

§ XXVII. *Phyſical Marks of Earths.*

Nor are we wholly to neglect the *phyſical marks*, which, though they cannot be fully eſtimated by the external ſenſes alone, yet may be aſcertained by eaſy experiments, without the trouble of decompoſition. Such, in the firſt place, are hardneſs and ſpecific gravity; to which, indeed, we may add the relation to the magnet.

§ XXVIII. *Hardneſs.*

Degrees of hardneſs may be determined in various ways, by the nail, the knife, or by ſteel; and,

* Eſſays, vol. 2.

and when they are more intenſe, by a ſeries of gems, cut expreſsly for this purpoſe. But this property indicates leſs the matter, and its mixture, than the various exſiccations ariſing from different circumſtances, the ſubtlety and coheſion of particles, denſity, and ſuch like. Soft clay dried gradually, and afterwards expoſed to an encreaſing fire for ſeveral hours, until it is brought to a white heat, becomes harder and harder, and is at length capable, like a flint of ſtriking ſparks from ſteel. In all this proceſs, however, the matter is no otherwiſe affected than by a contraction of its bulk, which is diminiſhed about one half.

§ XXIX. *Specific Gravity.*

SPECIFIC gravity is determined by the hydroſtatic balance, which properly indicates nothing elſe than the denſity or quantity of matter in a given volume. A knowledge of this property is of conſiderable utility, eſpecially in the examination of metals, whether pure, or of known mixture; but with reſpect to other foſſils, the difference is ſo very triffling, that their nature and compoſition can ſcarcely ever be this way aſcertained.

§ xxx. *Examination by the Magnet.*

Iron, unleſs it is dephlogiſticated below a certain point, is ever obedient to the magnet; but this mark is particular. Various phenomena likewiſe authoriſe a ſuſpicion that many other ſubſtances are attracted by it; therefore no reliance can be had upon this as a diſtinguiſhing character.

§ xxxi. *Real Utility of external and phyſical Marks.*

Although ſuperficial criteria contribute nothing to the true knowledge of foſſils, and that the obſervation of Juvenal, *fronti nulla fides*, may be well applied to them, even though the phyſical properties be at the ſame time underſtood, (§ xxviii. xxx.) yet we are not altogether to paſs them over in contempt. By ſuch accurate determinations as the celebrated Werner ſo ſucceſsfully attempted, they are rendered very proper for diſtinguiſhing varieties; and when the eye is once habituated to them, they often lead it directly to diacritic experiments. Perhaps the compoſition being thoroughly aſcertained by analyſis, an exact compariſon may aſſiſt conſiderably in drawing a juſt inference.

§ XXXII. *Nature of Foſſils diſcoverable by the Aid of Chemiſtry.*

IN order to diſcover the proximate principles of foſſils, it is neceſſary to have recourſe to chemical experiments. But will not the ſimpler kinds be ſufficient, in which the foſſils, whether alone, or with the addition of proper fluxes, are melted in the fire and treated in various ways? This indeed is the path purſued with indefatigable zeal by the celebrated Pott, and which no one ſince him has extended with more ſucceſs than the renowned Monſieur D'Arcet. How far it is connected with our deſign we ſhall preſently have occaſion to obſerve.

§ XXXIII. *Their Character in the Fire.*

A THOROUGH knowledge of the effects produced by fire upon foſſils is of the greateſt importance in the cultivation of many arts. For if we recollect that bricks, tiles, crucibles, glaſs, amauſa, earthen and china veſſels, eliquation of metals, and other works, can neither be carried on nor completed without the aſſiſtance of fire, we ſhall ſee that this knowledge is equally NECEſſARY and extenſive.

§ XXXIV.

§ XXXIV. *Use of the Blow-Pipe in Oryctology.*

NOR can we pass over in silence the great utility of the blow-pipe in oryctology, by its speedy and concise mode of operating. With it a few minutes are sufficient to examine the nature of a fossil, upon a piece of coal, or in a spoon of gold, and to observe all the changes from beginning to end; which for the most part is not possible in a crucible; notwithstanding in this way, it requires several hours before the result of the process can be known*.

§ XXXV. *Most of the Principles of Fossils are discovered by Fire.*

IT must, however, be acknowledged, that, in many cases, the principles of fossils may be ascertained by the proper application of fire; unless, by the number or delicacy of such principles, the composition of the fossil is rendered too complex and intricate.

§ XXXVI. *But not every Principle.*

THERE are many circumstances that will prevent us from considering fire as the supreme arbiter of composition, though supported with all the

* Essays, 2d vol. page 455.

the aſſiſtance of the dry way; and it may be ſufficient to enumerate ſome of the moſt conſiderable.

§ XXXVII. *Why Inveſtigation by Fire is ſometimes fallacious.*

FIRE tends to confound all principles together, except thoſe of metallic bodies which are ſeparated from their matrices; it is therefore not at all calculated to extricate the ſeveral ingredients of compoſition.

§ XXXVIII. *The Efficacy of Fire cannot be defined with any certainty.*

AN accurate and eaſy meaſure of the power of this element is yet wanting. A foſſil reſiſts a certain degree of heat, that will yield to one more intenſe; and there are perhaps a very few that are deemed altogether refractory.

§ XXXIX. *And it is variable alſo.*

IT is not uncommon for the ſame degree of fire to melt ſome varieties of the ſame ſpecies, while upon others, it ſeems not to have the ſmalleſt influence. The petroſilices, feltſpat, and other foſſils, afford examples of this kind.

§ XL.

§ XL. *Does not determine the Proportion of the different Principles.*

AND laſtly, if ſometimes it is competent to diſcover ſingle principles, yet it always conceals their mutual proportions. This imperfection is of the greater moment, as it is evident, that the proportions of the ſame materials being varied, both the appearence in the fire, and the other qualities of the foſſil, are often conſiderably altered.

§ XLI. *Merit of Cronſtedt.*

THE celebrated Cronſtedt, in his excellent ſyſtem of foſſils, has eſtabliſhed the ſuperiority of principles, and has therefore conceived the genuine method; and if, notwithſtanding, he has occaſionally fallen into errors, they muſt be attributed to the want of proper experiments.

§ XLII. *The beſt Method of examining Foſſils in the Humid Way.*

THE illuſtrious Margraf had no ſooner diſcovered the true method of decompoſition, the humid and menſtrual, than he endeavoured, by his own exertions to render it eaſy and practicable. The new road into which he ſtruck, was beſet with thorns and briars; but it is certainly the

only one that leads to a knowledge of principles, both as to quality and quantity; and therefore indiſpenſably neceſſary in every enquiry into compoſition.

§ XLIII. *The Difficulty of founding a Syſtem of Foſſils.*

It was the opinion of the celebrated Lehman, whoſe judgement in ſuch matters was unqueſtionable, that a thouſand years would not be ſufficient for the conſtruction of a ſyſtem of foſſils, arranged according to proximate principles, on account of the immenſe number of various foſſils, and the daily augmentation it is receiving; the variety and expence of the neceſſary experiments, and the want of a more general ſpirit of adventure and induſtry requiſite for ſuch an undertaking.

§ XLIV. *Internal and external Characters.*

A collection of thoſe properties on which the leading principles depend, is called the *internal character;* and the chief ſuperficial marks of any foſſil taken together, conſtitute the *external character.*

Of

Of the Classes of Fossils.

§ XLV. *Enumeration of the Classes.*

Avicenna, an Arabian physician of the eleventh century, divided fossils into the four classes, of salts, earths, metals, and phlogistic bodies. In this division, all substances agreeing either in external or internal character, are properly enough combined; and, as hitherto no general arrangement has been proposed preferable to this, it is no doubt worthy of being continued.

§ XLVI. *Order.*

The order of the classes may in a great measure be treated as a matter of indifference; however, I think it right to begin with Salts, as being the only substances soluble in water, and which ought to be thoroughly understood, in order to develope the nature of the other classes; and perhaps, because they are radically united with each of them, though the most considerable number of them have as yet in this state escaped discovery.

Phlogistic bodies I place the last in order; for these by their prevailing principle approach nearer than any of the other classes to organised bo-

dies, charged with inflammability, and to which principle foſſils perhaps are indebted for their exiſtence. Earths and metals, according to their character, hold with propriety a middle ſtation.

§ XLVII. *Diſtinguiſhing Marks of each Claſs.*

For the preſent it may be ſufficient to mention the following criteria of the claſſes, which ſhall afterwards be more fully explained.

Salts very finely pulveriſed, and diſſolved in a thouſand times their weight of water, are more or leſs ſenſible to the taſte. With reſpect to diſtilled water 2 is the common limit of their ſpecific gravity.

Earths have neither taſte nor ſolubility. They are however taken up by proper ſimple ſalts. Though for the moſt part heavier than ſalts, they are not reducible to a metallic ſtate. When compared with water, their ſpecific gravity fluctuates between 3 and 4½, which it has never yet exceeded.

Metals are not ſoluble in water; have a peculiar ſplendour; and ſurpaſs all other known bodies in ſpecific gravity. They are at leaſt ſix times heavier than equal bulks of water, commonly much more; but never exceeding twenty times.

Phlogiſtic bodies are almoſt always lighter than

than the ſalts; but have this peculiar quality of being combuſtible.

§ XLVIII. *Taſte.*

TASTE, depending upon the ſenſibility of the tongue, differs ſo much in different perſons, that what will excite powerful ſenſations in one man ſhall not be at all perceptible to another. It is evident, therefore, we are to place but little dependance on this quality.

§ XLIX. *Solubility in Water.*

SOLUBILITY in water, conſidered generally, is an *unlimited property*. In order to define it, it will be neceſſary to attend to the ſtate of diviſion of the body to be diſſolved, and the quantity and temperature of the menſtruum employed.

Pulverization encreaſes the extent of ſurface; and in proportion as it does ſo, the menſtruum, by coming into contact in a greater number of points, acts with more efficacy. For this reaſon large maſſes immerſed in a menſtruum, are ſometimes very little, if at all corroded: When divided into ſmall pieces they offer leſs reſiſtance; and, if pulverized are entirely diſſolved. It happens occaſionally, however, that mechanical diviſion does not anſwer the end effectually,

and therefore recourſe is had to the more ſubtile powers of chemiſtry; and the precipitation of a ſolution made in a ſtronger menſtruum, is taken ſucceſsfully for this purpoſe. For a precipitate yet moiſt and recent is ſo open and ſpongy, that it far exceeds all mechanical diviſion.

In like manner, though a ſolution cannot be effected in an equal weight of water; yet, if that weight is doubled or tripled, or ſufficiently encreaſed, there would be no doubt of producing it.—If water of a moderate temperature avail nothing, tepid or warmer water may ſucceed; and ſhould this degree alſo of heat be ineffectual, it may yet be raiſed to ſuch a height in a cloſe veſſel, as will generally overcome all reſiſtence, and even produce effects ſcarce to be expected.

Hence, then, I apprehend it is evident, that the very nature of ſolubility will not admit of any certain or determinate criteria, but that it may be ſaid rather to proceed in an infinite ſeries: For if, on inſtituting an experiment, nothing is diſſolved, a ſuſpicion will always ariſe that if the reſiſting matter were either more minutely divided or immerſed in a greater quantity of water, or in water of a higher temperature, it would neceſſarily be diſſolved. In this manner, therefore, all certainty is deſtroyed, and every concluſion rendered merely conjectural.

§ L. *Artificial Limits of Solubility.*

If ſolubility ever becomes an uſeful criterion, it muſt be by aſſigning to it certain neceſſary artificial limits. Having duly conſidered this idea, I have pronounced thoſe to be the beſt, that can be found moſt eaſily every where. I have ſelected therefore for this purpoſe mechanical pulverization, a weight of water a thouſand times heavier than the ſubſtance to be diſſolved, and a degree of heat equal to boiling, as boundaries more proper than any others.

§ LI. *Great Extent of Solubility.*

We are very far from believing that this limit is to interrupt one link in the great connecting chain of nature. Our ignorance and weakneſs have rendered it neceſſary; and, whatever ſubſtances beyond it a more improved ſtate of ſcience may diſcover, we ſhall refer them to the claſs of earths, though we give them the appellation of ſaline, as an indication of their character. As examples of ſuch ſaline ſubſtances, we may take the ſiliceous earth, which is found abſolutely diſſolved at Geyſer in Iceland *; and the zeolithic, at Laugarnaes in the ſame iſland †.

* Eſſays, vol. 3d. p. 251.

† Ibid. p. 255.

Vitriolated ponderous earth, commonly called *ſpatum ponderoſum*, aerated lime *, fluorated lime, impregnated with the acid of the *lapis ponderoſus* †, are all ſaline earths, by the force of compoſition, and are even without doubt ſoluble, though to what extent experience has not yet determined.

§ LII. *Diſtinguiſhing Marks of Earths.*

THE characters of earths are of the negative kind. An earth is that ſubſtance, which is not ſoluble; not ſo heavy as metallic bodies, nor is capable of combuſtion. Criteria ſuch as theſe betray our very limited and imperfect knowledge. Cronſtedt indeed mentions another mark, the malleability of earths; but this obſervation may be applied to ſalts, phlogiſtic ſubſtance, and the brittle metals. As to their form not being changed by a red heat, the ſame can be ſaid of the vitriolated vegetable alkali, of metals that require a much greater degree of heat for their fuſion, and of other foſſils. Any expanſion of their bulk is ſcarce perceptible to the eye, though a red heat is always ſure to produce it, unleſs counteracted by the diſſipation of ſome volatile matter, as in clay, aerated lime, and other ſubſtances.

§ LIII.

* Vol. i. p. 26.
† Vol. iii. p. 228.

§ LIII. *Metals.*

PERFECT metals are eaſily diſtinguiſhed by their opaque ſhining ſurfaces and ſpecific weight. Their malleability, which Cronſtedt conſiders as their peculiar character, is no general criterion; for we reckon almoſt as many brittle as ductile metals.

§ LIV. *Phlogiſtic Subſtances.*

A CERTAIN degree of levity, with as much phlogiſton, looſely combined, as will occaſion inflammation, is neceſſary to the conſtitution of all bodies denominated phlogiſtic. Solubility in oil is not a diſtinguiſhing property of this claſs; as that menſtruum, though producing no effect on plumbago, yet acts violently on lead, copper, arſenic, and other metals.

§ LV. *Mixed Foſſils.*

WHILE we are giving our attention to the diſtinct arrangement of the ſeveral claſſes, it will be eaſily ſeen that we mean to conſider ſuch foſſils only as are in a ſtate of purity; that is to ſay, free from every corruption by combination with the ſubjects of other claſſes, not neceſſary to their compoſition. Sulphurated metals, for example, belong to two claſſes; and we are

to

to determine from other data, to which they ought in preference to be adjudged. In like manner, aerated and fluorated lime, muriated ſilver, and ſome others are to be conſidered.

§ LVI. *Affinity of Foſſils.*

By the law of continuity, we may obſerve a great affinity among the ſeveral claſſes of foſſils.

§ LVII. *Affinity of Salts with Earths and Metals.*

We have already taken notice of the connexion of ſalts with earths, and we may add further to our remarks on this ſubject, that burnt lime, by the intermedium of the matter of heat, acquires a ſolubility perfectly ſaline. The ſame thing happens to ponderous earth, but not to magneſia. In all metals there lurks a certain acid peculiar to each, the nature of which we have as yet explored in arſenic only. Theſe metallic acids differ from all others in this reſpect, that, when taken with proper proportions of phlogiſton, they become metallic calces; but if ſaturated with that principle they are reduced to a perfect metallic ſtate *, generating at the ſame

* Eſſays, vol. 3. p. 124.

ſame time ſulphur and aeriform fluids *. Moſt phlogiſtic bodies likewiſe, perhaps indeed all, contain an acid united in their very conſtitution.

§ LVIII. *Affinity of Earths with Metals.*

EARTHS reſemble the calces of metals in many of their properties; but in reſpect to ſpecific gravity, the faculty of colouring glaſs, and their reduction to the metallic ſtate, they are eſſentially different.

§ LIX. *Sulphureous Character of Metals.*

METALS in their perfect ſtate are either metallic acids ſaturated with phlogiſton, or a ſpecies of metallic ſulphur, which are ſometimes very evidently ſuſceptible of inflammation, as zinc and arſenic. Gold and copper, when in fuſion, afford ſome appearance of flame, though faint, in a greeniſh vapour; bright ſparks are emitted from iron in a white heat; and tin alſo may be inflamed by a proper manner of operating.

§ LX. *Stones.*

IN the claſſes already enumerated, all foſſils are by no means included. Such as are compoſed

* Eſſays, Vol. ii. p. 352.

ſed of heterogeneous ſubſtances, mechanically mixed, and united in a viſible manner, and which, for the moſt part, conſtitute the entire ſummits of mountains, are comprehended under one name of *Petræ* or *Saxa*. Cronſtedt has, with great propriety, treated theſe ſeparately in an appendix. The knowledge of theſe ſubſtances is doubtleſs highly neceſſary, and tends much to the illuſtration of phyſical geography; but they are not therefore to be confounded with bodies more homogeneous, whoſe combination reſting on chemical principles, is effected in the way of ſolution.

§ LXI. *Organic Foſſils.*

ORGANIC foſſils are conſidered by Cronſtedt in another appendix. Theſe ſubſtances are to be treated as ſtrangers from the animal or vegetable kingdom. They are diſtinguiſhed by an organic ſtructure, more or leſs imperfect; of which, as long as they bear any marks, we are to reckon them as foſſils of a foreign ſpecies. The conſideration of them is however in various points of view, highly uſeful. They reſemble a ſeries of ancient coins in the teſtimony they bear to the convulſions and revolutions of our globe, on which hiſtorical monuments are wholly ſilent. From them we may learn the wide extended ſovereignty of the ſea; the changes that

that ſucceſſive ages have wrought upon the ſurface of the earth; and they diſcloſe to us what animals inhabit the deep abyſſes of the ocean, and many other circumſtances moſt worthy the attention and enquiry of philoſophy.

§ LXII. *Volcanic Productions.*

THOSE burnt ſubſtances thrown out from the mouths of volcanos, by a greater or leſs degree of ſubterraneous fire, Cronſtedt has thought fit to arrange in a third appendix. A general view of them no doubt would be uſeful; but there are not wanting many reaſons why, in my opinion, volcanic productions will not admit of a ſeparate claſſification. We know there are many who ſtrenuouſly ſupport the hypotheſis, that the whole foſſil kingdom owes its origin to fire; for ſuch as theſe, therefore, any diſtinction will be unneceſſary. We have learned alſo, that marks burned by fire into foſſils are gradually obliterated by the injuries of time; becoming firſt obſcure, then equivocal, and at length being wholly deſtroyed. Whatever limits, therefore may be drawn, they are in their very nature tranſient and periſhable. It is, and muſt be often exceeding difficult to determine whether foſſils have derived their exiſtence from ſolution, or from the effects of fire. Accordingly, to me it ſeems proper, to inſert homogeneous volcanic

volcanic productions into claſſes agreeable to their principles; and that all thoſe heterogeneous ſubſtances, whoſe combination is viſibly mechanical, ſhould be the ſubject of the firſt appendix.

Of Genera.

§ lxiii. *Arrangement of Genera.*

By the aſſiſtance of claſſes, all thoſe foſſils are connected, whoſe compoſition, character, and properties are perfectly ſimilar. Genera require a nearer affinity; ſpecies a reſemblance ſtill cloſer; and varieties muſt correſpond in their internal habitudes only.

Foſſils entirely homogeneous are of very rare occurrence; as, for the moſt part, two, three, or more principles, enter into their compoſition.

The more ſimple their compoſition, it follows, they will be the eaſier reduced to their natural genera.

Let A and B be the proximate principles of any foſſil, let A be heavier than B, the compound A B, will be then referred to the genus of A; but this admits of various exceptions.

Suppoſe B poſſeſſed of a generic difference, and that it is no where found in a ſingle ſtate, (for we do not here ſpeak of artificial ſeparation,)

on), but always united to A, or ſome other matter, and ever inferior in weight in ſuch combinations. According to the rule propoſed above, the genus B ſhould diſappear entirely, and be altogether wanting in the genera of its own claſs, which is by no means conſiſtent with a natural ſyſtem.

Again, let us ſuppoſe B excels A in the intenſity of its properties, ſo that B is only equal in weight to $\frac{A}{N}$, yet notwithſtanding the qualities of B are clearly predominant in the compoſition A B, that is, are much more conſpicuous than thoſe of the leſs ingredient A. Here again, unleſs I am deceived, we are to admit another exception.

If the caſes propoſed under B and C obtain at the ſame time, the exception receives a double confirmation.

Sometimes it ſeems neceſſary to give a preference to the price of particular ſubſtances. Suppoſe A B C an ore, whoſe metal C, though of leſs weight than any other part of the mixture, yet in value ſurpaſſes both B and A, ſo that they are entirely neglected, and C only thought worthy the expence of metallurgic operations. In this caſe A B C is in fact the ore of C; but if the proportion of quantity were regarded, it ſhould belong to the genus of A, and with great propriety, if a natural ſyſtem only is required.

We

We are not here to have any reſpect to fictitious valuation. But as the arrangement of foſſils is made with a view that our knowledge of them may be eventually uſeful and advantageous, it may ſeem to militate againſt this deſign, if we were to ſeek among the baſer kind for all thoſe noble minerals, whoſe intrinſic value can defray the labour and coſt of eliquation.

The ſeveral caſes propoſed ought not to be conſidered as imaginary, as they each of them occaſionally occur, and will be rendered more clear and intelligible by application in the following ſections.

§ LXIV. *Genera of Salts.*

In ſalts, we diſcover two genera, by no means ambiguous; the acid, and the alkali. Chemiſtry has not yet been able to extract their proximate principles; but, that they are different from, and oppoſite to each other, there is not the leaſt room to doubt.

§ LXV. *Acids.*

An acid is eaſily diſcoverable by the taſte, by its property of changing to red the blue vegetable colours, and of effervеſcing with aerated alkalis.

§ LXVI. *Alkalis.*

ALKALIS are diſtinguiſhed by a burning taſte, by their converſion of blue vegetable colours to a green, and by their powerful attraction for acids.

§ LXVII. *Salts not ſaturated.*

UNSATURATED combinations of acids and alkalis, enter the genus of the prevailing ſubſtance, unleſs any one ſhould chuſe to refer them rather to the imperfect neutral ſalts; which might be done not altogether without reaſon, as the moſt of them betray an exceſs of either the one or the other ingredient.

§ LXVIII. *Whether neutral Salts are to be referred to a diſtinct Genus.*

IT may be queſtioned whether an acid exactly ſaturated with an alkali ſhould conſtitute a diſtinct and ſeparate genus? Or ought rather ſuch a combination to be ranked under the acid, or the alkaline ſalts? If there is evidently an exceſs of either of theſe principles, as in § 75, then, without doubt, it may be properly aſſigned to the genus of the exceeding principle; but, in all perfect neutral ſalts, the properties of acid and alkali are blended ſo intimately by ſaturation, that all diſtinction between them ſeems en-

tirely to have diſappeared. In this ſtate of equilibrium, then, it becomes a matter of indifference whether the preference be given to the acid or the alkali. To the latter however I ſhould rather incline, as the moſt convenient; but I would not violently oppoſe any one who might think proper to refer them to the acid, or to a diſtinct genus. Quantity may in this caſe, in ſome meaſure, aſſiſt our determination; but not without irregularity: For, as the pure fixed alkali is ſaturated with a weight of acid leſs than its own; ſo, on the other hand, the volatile alkali requires the acid to be heavier than itſelf.

§ LXIX. *Mixed Neutral Salts.*

It may happen, that the ſame acid is partly ſaturated with one alkali, partly with another; and yet nevertheleſs, theſe three are ſo ſtrongly united by cryſtallization, as to conſtitute but one peculiar ſalt. The ſalt of Seignette affords an inſtance of this ſpecies of compoſition; the cream of tartar likewiſe ſaturated with volatile alkali. That the ſame alkali may be combined with two acids, the union of cream of tartar with the acid of borax ſufficiently demonſtrates. In the foſſil kingdom, indeed, we find none of theſe triple ſalts; but they inform us what may be done towards eſtabliſhing a general arrangement. The ſalt of Seignette, with the acid of borax

borax, produces a quadruple ſalt; and it is not unlikely, but that the induſtry of future ages will diſcover combinations of five principles, and perhaps of ſtill more; the diſpoſition and order of which may be determined by the character and quantity of the ſeveral ingredients.

§ LXX. *Analogous Salts.*

FOSSILS of the ſecond and third claſs become true ſaline ſubſtances, by combination with any ſalt; and in this condition they are baniſhed from their original claſſes. Salts, ſuch as theſe, are called, analogous; and according to the character of their baſes, are of two kinds, either earthly or metallic. Whatever imparts the ſaline nature ought to determine the genus.

§ LXXI. *Other Combinations of Salts.*

ALL earths almoſt as well as metals are not only taken up by acids, but ſeveral foſſils beſides, of both claſſes, are diſſolved by alkaline ſalts, and ſome even by neutral ſalts; nay, it happens occaſionally, that two double ſalts will unite into one, and form a ſalt of four principles. From ſuch multiplied and various combinations proceed, alkalis and acids charged with earths and metals; double neutral ſalts, or ſalts of more principles, containing earths and metals; double earthy ſalts united with double metallic ſalts,

which, according as the ſaline matter is either the ſame or different in each, generate triple or quadruple compounds.

§ LXXII. *Doubtful Genera of Salts.*

In the claſs of ſalts it often happens, that ſome principles are never found in a ſingle and independent ſtate, but united always with others. Such are, for example, the nitrous, the muriatic, and arſenical acid. It may be doubted, therefore, whether theſe ſubſtances are to be conſidered under their ſimple genera. As, however, it does not ſeem improbable, that they were once free and uncombined, we are hardly authorized to exclude them; though it may be, at the ſame time, obſerved, that they have never yet been found otherwiſe than in this ſtate of combination. At all events, the inveſtigation of ſimple ſubſtances will throw light upon the ſeveral compoſitions.

§ LXXIII. *Genera of Earths.*

Some genera of earths have hitherto reſiſted all attempts to reduce them into ſimpler principles; while others, by a proper analyſis, have diſcovered two or more. The former are called *primitive*, the latter, *derivative* earths.

§ LXXIV.

§ LXXIV. *Primitive Earths.*

CRONSTEDT has eſtabliſhed nine primitive earths, but accurate experiments have ſince ſhewn that the greater number of them were compounded, ſo that the account is reduced to three only; the calcareous, ſiliceous, and argillaceous. We have however to add new earths, with which he was not acquainted, the terra ponderoſa and magneſia. We reckon therefore five primitive earths.

§ LXXV. *Of the common Origin of Earths.*

ALTHOUGH the powers of chemiſtry have not yet been able to decompoſe theſe five earths, the reduction of them all to one ſpecies, or, at leaſt, to a ſmaller number than the preſent, may poſſibly be the reward of future induſtry. I acknowledge myſelf of this opinion, and I think with ſome foundation. Clay, for example, is nothing elſe than calcareous earth, ſo ſtrictly combined with ſome unknown acid, that the ſeparation of them has hitherto been attempted in vain. No one certainly could have ſuſpected the calcareous baſe in the *lapis ponderoſus*, which has been demonſtrated by analyſis. In like manner, other ſubſtances may be inveſtigated. But until proper experiments ſhall have fully developed the nature of ſuch compoſitions,

they muſt be, in reſpect to our knowledge of them, conſidered as primitive ſubſtances: For it is wholly inconſiſtent with the caution and diffidence of natural philoſophy to advance any poſition upon a bare poſſibility. Daily experience ſufficiently teaches, that thoſe things which at one time appear highly probable, may at another be diſcovered to be entirely unfounded.

§ LXXVI. *Reaſons why the Terra Ponderoſa ought to be referred to a diſtinct Genus.*

THE ponderous earth, on account of its great ſpecific gravity, is deſerving of particular attention, and leads us naturally to apprehend it to be of metallic origin. Other arguments alſo ſupport this hypotheſis. It is admitted, with the force of an axiom, that phlogiſticated alkali precipitates metallic ſolutions only: But if this alkali is dropped into a ſolution of acetated ponderous earth, it is immediately diſturbed, and a white powder is precipitated; which, on examination, is found to conſiſt of that earth vitriolated, from the vitriolic acid inherent in the Pruſſian blue. If the powder is ſeparated by means of a filtre, and a new portion of acetated ponderous earth added to the liquid, on expoſing it to the fire, the ſolution, though clear before, depoſits another white powder, containing the ponderous earth united with the phlogiſtic alkali. The reſult is the ſame if the ponderous earth

earth, ſaturated with the nitrous acid is treated in a ſimilar manner: Therefore it ſeems rather to reſemble a metallic calx than an earth, by theſe properties.

Among the metallic calces, that which ariſes from lead correſponds with the ponderous earth in its weight, its white colour, and peculiar attraction for the vitriolic acid, by which that acid is torn away from alkaline ſalts; but there is notwithſtanding a remarkable difference between them. Acetated lead is diſturbed wholly in the cold by phlogiſticated alkali, and depoſits a ſediment, which neither is ſoluble in water, nor in the vitriolic acid; but the acetated ponderous earth yields its genuine precipitate by heat only, and which is ſoluble both in the vitriolic acid and in boiling water. Beſides, this earth has hitherto reſiſted all efforts to reduce it to a metallic ſtate.

Therefore, although there may appear a conſiderable affinity between the ponderous earth and a metallic calx; yet, as long as it is incapable of reduction, its metallic nature is certainly not ſufficiently demonſtrated, and it muſt ſtill retain a place among the earths.

§ LXXVII. *Five Genera ſhould be conſtituted of the five primitive Earths.*

As we have enumerated already five primitive earths, they naturally become the heads of

five diſtinct genera. It is very rare, if ever, that they are found in a ſimple ſtate, being either combined with one or more of the other earths. The moſt eaſy method, therefore, would be to determine the genus of every ſuch compoſition, according to the heavieſt principle; but the caſes before ſeparately ſtated, in § lxiii, are often objections to this plan.

§ LXXVIII. *Exceptions.*

WERE this rule once admitted, we ſhould loſe altogether the magneſian and argillaceous genera; for, in the compoſitious hitherto examined, into which thoſe earths enter, the ſiliceous has been always found to outweigh the others, although, from their character and properties, they had both the ſuperiority. Common clay contains above half its weight of ſiliceous earth, ſometimes above three fourths, and yet the argillaceous qualities are ſo diſtinct, that theſe compoſitions are unanimouſly denominated argillaceous. The ſame richneſs and pre-eminence of quality, with reſpect to the ſiliceous earth, are found in magneſia, and other ſubſtances.

All earthy compoſitions, therefore, may be determined by the genus of that ingredient, which exceeds the others in weight, unleſs it be ſiliceous, and not equal to ſeven-eights of the whole. In ſuch caſes, the genus ought to be aſcertained

aſcertained by whatever ingredient aproaches neareſt in weight to the ſiliceous.

§ LXXIX. *Compounded Earths are not united mechanically only.*

BUT perhaps, all earthy compoſitions are nothing elſe than many ſubtle mechanical mixtures? At the very firſt view indeed there ſeems ſome foundation for ſuch an opinion; but a more minute inveſtigation furniſhes evidence of a cloſer union conſtructed on other principles. The earth of alum immerſed in lime-water, and entering into ſo ſtrict a combination with the lime as not to be ſeparable but by chemical art, teaches us, that among primitive earths mutual attraction has a real exiſtence. Beſides, as almoſt all theſe mixtutes generally form cryſtaline concretions, we have another proof, not only of the minuteneſs of their particles, but of an union perfectly homogeneous.

§ LXXX. *Genera of Metals.*

IN the third claſs we are to conſtitute as many genera, as we have known diſtinct metals.

§ LXXXI. *Encreaſed within a few Years.*

AT the beginning of the preſent century, eleven

eleven metals only were known; but it had ſcarce grown forty years older, before the diſcovery was made of platina, a noble and ductile metal, and of three or four others, that were not malleable, as cobalt, niccolum, magneſium, and ſiderum, which laſt has hitherto appeared to differ from all the reſt *. The fifth in molybdena is not yet ſufficiently explored, to determine whether it ſhould be reckoned among thoſe already known, or conſtitute a new ſpecies; and to the ſixth, in the acid of the lapis ponderoſus, we may apply the ſame obſervation. Of theſe two, however, we are in hopes the character of the firſt will be ſoon diſplayed by the induſtry of Mr Hielm. The genera of metals, therefore, of which we can be certain, amount to ſixteen, or fifteen at leaſt; and it is not unlikely that this number will be increaſed by future diſcoveries.

§ LXXXII. *Arrangement of mixed Metals.*

IN ſection lxiii. we have a queſtion reſpecting the genera of minerals containing two metals, the one of which is more valuable than the other, but in leſs quantity. Examples of ſuch minerals we find in the golden pyrites, which hold

* Meyer and Klaprothius have proved it to be iron joined to the phoſphoric acid; and our author, convinced by their arguments, changed his opinion.

hold a ſmall proportion of gold united with a large proportion of iron; among the galenæ, that are far richer in lead than in ſilver; among the copper pyrites, always producing more iron than copper; and ſo on of many others. According to ſyſtematic rules, the more valuable and ſcarcer metal, although it defray the expence of eliquation, ſhould yet be referred to the genus of the more abundant, though of leſs eſtimation. But if the uſe and aim of any ſyſtem is conſidered, there can be no doubt that the preference ſhould be aſſigned to the metal of the higheſt value. In ſome degree, however, the determination of this point may be a matter of indifference, provided no diſtinct genus is thereby deſtroyed; a circumſtance that would probably affect the ſiderite, in caſe it were decided in favour of ſuperiority in weight, as that metal has never yet been found ſeparate from iron ores, to which it always bears the ſmalleſt proportion.

§ LXXXIII. *Genera of Phlogiſtic Bodies.*

THE fourth claſs contains the feweſt genera, ſulphur, petroleum, amber, and perhaps diamond.

§ LXXXIV. *Sulphur.*

SULPHUR is an inſtance of the moſt ſimple compoſition, conſiſting of two principles only, acid ſaturated with phlogiſton.

§ LXXXV. *Petroleum.*

IN petroleum we diſcover an union more complex; a ſmall portion of water combined, by means of an acid, with the principle of inflammability.

§ LXXXVI. *Amber.*

THE origin of amber is evidently from the vegetable kingdom, for, beſides its peculiar acid and oil, we obtain the acetous acid by diſtillation. The earthy reſiduum may be conſidered as a matrix.

§ LXXXVII. *Diamond.*

WITH regard to the diamond, I have hitherto found no place ſo proper for it as this claſs. In a ſufficient degree of fire, it is entirely conſumed, and with an appearance of cloud or flame; and, in the focus of a burning lens it diſcovers ſigns of a ſooty matter.

§ LXXXVIII.

§ LXXXVIII. *Pyrites and Molybdena do not conſtitute peculiar Genera.*

I HAVE referred pyrites, or ſulphurated iron to the genus of iron. In like manner, molybdena, which is nothing elſe than a metallic calx mineralized by ſulphur, provided its genus were known, ought to be aſcribed to the claſs of metals. As to the foſſil conſidered by Cronſtedt as fixed phlogiſton, and which he calls *brandertz*, its compoſition has not as yet been ſufficiently inveſtigated.

§ LXXXIX. *Properly ſpeaking, there is but one Genus of phlogiſtic Subſtances.*

IN the ſtrictneſs of language, all the genera of this claſs might be reduced to one, as the ſame principle of inflammability prevails in each of them.

§ XC. *Firſt Appendix.*

IN the firſt appendix to the claſſes, are treated thoſe foſſils of various and mechanical combination, and which for the moſt part is obvious to the ſight.

§ XCI. *Four Genera of Foſſils mixed mechanically.*

ANSWERING this deſcription, we have four genera only, which are denominated according to the claſs of the moſt predominant ingredient in their compoſition.

§ XCII. *Firſt Genus.*

THE firſt genus in which the ſaline character prevails occurs ſometimes in the neighbourhood of volcanoes. In gypſum alſo other foſſils intimately mixed are occaſionally found. The ſubſtances likewiſe contained in natural waters may perhaps be referred to this genus. They are indeed held by water in ſolution, but their union is generally merely mechanical, of which the fixed principles are collected in the reſidua, after the evaporation of the liquor.

§ XCIII. *Second Genus.*

To the ſecond genus we aſſign all thoſe foſſils in which the earthy principle abounds. Such are thoſe placed by Cronſtedt in his firſt appendix under the name of *ſaxa*. Under this genus may be arranged ſeveral matrices of metals as well as of inflammable ſubſtances; for lithanthrax,

thrax *, aluminous ſchiſtus, aluminous ore of La Tolfa, and many others, contain ſome extraneous earthy matter, and in conſiderable quantity.

§ XCIV. *Third Genus.*

IN the third genus, the metallic nature is predominant. It has been long obſerved, that ſome metals affect a diſpoſition to aſſociate with each other; ſo that if one is diſcovered, it may be properly conjectured that the other is not very far diſtant. Relations ſuch as theſe, as are obvious in this genus, are worthy attention and enquiry, as they promiſe no ſmall advantage to the inhabitants of mountainous countries.

§ XCV. *Fourth Genus.*

IN the fourth genus we meet with various mixtures of foſſils, of which this ruling principle belongs to the laſt claſs.

§ XCVI. *Diſtinct and mixed Particles of Foſſils.*

To this appendix likewiſe, the diſtinct and mixed particles of foſſils may conveniently be referred, inſerting them under their proper genera, according to circumſtances. Such, for example

* Pit coal.

example are the marles, moſt of the common clays, mixed ſands, and ſeveral others.

§ XCVII. *Four Genera of organic Foſſils.*

LASTLY, Organic foſſils are divided into four genera, as the diverſity of their nature ſuggeſts, whether they are found impregnated with and compoſed of ſalts, earth, metals, or phlogiſton.

§ XCVIII. *Fifth Genus of Cronſtedt.*

CRONSTEDT adds a fifth genus, and perhaps with great propriety, in which are included all the dead remains of once living ſubſtances, which, by gradual putrefaction, have loſt their original ſtructure, though they ſtill retain ſuch ſtrong marks of it as are not obliterated entirely but by the lapſe of many years. To this genus belongs the earth of deſtroyed animals or vegetables.

§ XCIX. *Organic Bodies mineralized by Salts.*

THIS operation muſt vary according to the nature of the ſubſtance. Bodies immerſed in a ſalt ſolution are ſometimes penetrated by it, and indurated. In this manner the entire bodies of men, that had fallen by accident into the vitriolated water of the mine of Fahlun were found after

after ſeveral years, ſo little changed to the eye, that the individual could be remembered by his countenance: In other reſpects however they were rigid like a ſtatue, formed of ſaline matter. When expoſed to the free air they began to crack. By a ſimilar proceſs, no doubt, even ſofter ſubſtances may be ſo hardened, as to preſerve their ſtructure a long time, exempt from putrefaction.

§ c. *Bodies impregnated with Bitumen.*

In like manner organic bodies, impregnated with bituminous matter are enabled to preſerve themſelves from decay, and retain their figure and ſtructure.

§ ci. *Petrifaction of organic Bodies.*

Neither the bodies of animals nor of vegetables can be wholly penetrated by ſtony particles. The harder parts only, as the bones, ſhells, external covering, roots, woods, fruit, and ſimilar ſubſtances, are liable to this change; which, if I miſtake not, proceeds in the following manner: At firſt, the parts of ſofteſt texture putrefy, and leaving ſeveral empty ſpaces, through which water loaded with earthy particles paſſes, and in its courſe depoſiting them, the vacuities are at length filled by their gradual accumulation. Then follows the deſtruction of the more firm conſiſtence, to be penetrated in the ſame order.

If the later depoſitions differ in their colour and properties from thoſe of an earlier date, yet the original organic ſtructure is beautifully diſplayed by ſmooth and poliſhed ſections of the different bodies. All the particles, however, of the bodies ſo deſtroyed are not always carried off; for it often happens in diſtillation, that ſuch are expelled as ſhew ſigns of an organic conſtruction.

§ CII. *Organic Bodies penetrated with metallic Particles.*

THE moſt ſubtle metallic molecules, that can poſſibly be carried along by water, may in the ſame manner penetrate and change the harder organic parts.

§ CIII. *Nuclei.*

FROM the ſubſtances already deſcribed, nuclei have, with great propriety, been conſidered as quite diſtinct. They are produced by two different proceſſes. Any body poſſeſſing a ſhell or firmer covering, and depoſited in a ſoft ſtratum, is gradually attacked in its fleſhy parts and ſoft inteſtines, which are either wholly deſtroyed, or contracted by exſiccation; ſo that room being made in this manner for the particles flowing in, the ſhell is at length filled with a nucleus, bearing the marks of its internal ſurface. If a body is involved in ſediment, and after the exſiccation of the ſtratum is any way deſtroyed

deſtroyed or carried off, a nucleus will be formed in the cavity, deſcribing its external features.

§ CIV. *Remaining Impreſſions of organic Bodies.*

In any ſoft ſubſtance, impreſſions are left by cockles, ſnails, inſects, fiſhes, and other ſmall animals of the firmer kind, either of their external ſurface, their bones, or ſkeletons.

CV. *Oſteocolla.*

In particular ſoils, living roots are by degrees covered with ſo hard a cruſt, as to prevent the abſorption of the neceſſary juices. When a vegetable attracts moiſture every where in the neighbourhood of its root, the ſubtile, calcareous, argillaceous, ſiliceous, and even ochreous molecules, that accompany it, produce this effect. The fluid in which they were borne being abſorbed by the roots, they fix themſelves on the ſurface, and there forming a covering impervious to water, the roots decay, putrefy, and leave this cruſt, which is commonly called *oſteocolla.*

§ CVI. *Incruſtated organic Bodies.*

Waters loaded with earthy particles frequently cover with a cruſt, reeds, ſmall bran-

ches, and other ſubſtances immerſed in them, without any alteration of their original form.

Of the different Species.

§ cvii. *Specific Characters of Salts.*

Specific characters are to be determined by the difference in the nature of thoſe ſimple ſalts, which art has not been able to compoſe from their principles. Of theſe, two diſtinct genera only are known; the acid and the alkali already mentioned.

§ cviii. *Species of Acids.*

The genus of acids is very extenſive. The vitriolic, nitrous, and muriatic, have been extracted from foſſils for many ages paſt; but the diſcovery of others differing evidently from theſe has been made within a much later period. The acid of fluor, borax, arſenic, ſiderite, molybdena, and lapis ponderoſus, are of this deſcription *.

§ cix. *Vegetable Acids.*

We have the proſpect as yet of a more extenſive field in the acids of the vegetable kingdom. Beſides,

* For metallic acids, ſee Eſſays, v. iii.

Beſides the acetous, which was the only one formerly known, it has produced to us already the acids of ſugar, ſorrel, tartar, benzoin, citron, amber, and ſeveral others.

§ CX. *Animal Acids.*

THE animal kingdom is the pooreſt of the three; for except the acid of ants, and of fat, we know of none other proper to it, although, without doubt, it contains many highly deſerving of notice. As for example, the acid which the larva phalænæ vinulæ of Linnaeus throws out in its defence, clear as water, and colourleſs, which reſembles the concentrated acetous acid in ſmell and taſte, coagulates blood, and thickens ſpirit of wine; reddens blue paper for a ſhort time; but the original colour returning afterwards, affords proof of its great volatility *. The ſcarcity of this very ſingular liquor has perhaps delayed ſo long its further inveſtigation.

§ CXI. *Acids common to ſeveral Kingdoms of Nature.*

OTHER acids are common to all the kingdoms of nature, as the *phoſphoric*, which had been falſely aſſigned to the animal kingdom alone; but which has been found, though rarely, in the foſſil †, and in great plenty in the vegetable

* Oeuvres de M. Bonnet, v. iii. 8vo. p. 28.

† Eſſays, vol. ii. page 426.

kingdom. Under this head we may arrange the aerial acid.

§ CXII. *Great Number of Acids.*

If we conſider, that probably the exiſtence of all metals depend upon their peculiar radical acids; that vegetables evidently contain a number of unknown acids; and that, perhaps, the ſame may be ſaid of animals alſo; we have reaſon to wonder at the abundance and variety of this ſubſtance, and to ſet a high value on its utility and importance in the œconomy of nature.

§ CXIII. *Species of Alkaline Salts.*

The extent of the other genus is confined within very narrow limits. For a long time three ſpecies only of alkaline ſalts were known; two of which could bear a ſlight ignition, and were therefore denominated fixed; while the other was diſtinguiſhed by its volatility.

§ CXIV. *Fixed Alkalies.*

Of the fixed alkalies the one ſeems to prevail in the vegetable, and the other in the mineral kingdom; from which they both derive their names.

§ CXV.

§ CXV. *Neutral Salts.*

SALTS formed by the exact ſaturation of acids with alkalies amount to ſixty double ſpecies, on the ſuppoſition that the acids do not exceed twenty in number. A conſiderable part, however, of the combinations of theſe are as yet unknown, or at leaſt but imperfectly examined.

§ CXVI. *Imperfect double Salts.*

MANY imperfect double ſalts have been diſcovered. The acids of vitriol, arſenic, tartar, and ſorrel unite in exceſs with the vegetable alkali; and the acids of vitriol and tartar with the mineral alkali. The labours of poſterity will probably add a greater number. Borax retains an exceſs of alkali; and the arſenicated mineral alkali likewiſe is capable of a ſimilar combination.

§ CXVII. *Triple Salts.*

THE ſalt of Seignette, and tartar ſaturated with volatile alkali, furniſh examples of the neutral triple ſalts.

§ CXVIII. *Imperfect Triple Salts.*

AMONG the triple imperfect ſalts, we know of the union of tartar with the acid of borax. Here is an exceſs of acid.

§ CXIX. *Quadruple Salts.*

TARTAR and borax combined, are an inſtance of the quadruple ſalts.

§ CXX. *Species of analogical Salts.*

EARTHS and metals, although ſingly they refuſe every combination with water, yet by the admixture of a ſalt they become for the moſt part ſoluble, and are then called analogical ſalts.

§ CXXI. *Species of double perfect earthy Salts.*

FOUR primitive earths uniting with twenty acids, produce eighty double perfect earthy ſalts; that is ſalts compleatly ſaturated. The fifth earth, the ſiliceous, is ſoluble in the fluor acid only.

§ CXXII. *Double imperfect earthy Salts.*

OF all the double imperfect earthy ſalts, with an exceſs of acid, the ſalt of alum is the moſt conſpicuous.

§ CXXIII. *Triple earthy Salts.*

THE principle triple compounds, are the volatile alkali, either vitriolated or muriated, and magneſia, with which even nitrated lime readily unites.—Vitriolated magneſia combines with clay; and both the vegetable and mineral alkali ſaturated with the acid of fluor, admit an union with ſiliceous earth.

§ CXXIV. *Earthy alkaline Salts.*

FIXED cauſtic alkalis, I know for certain affect no other earths than the argillaceous and ſiliceous. No triple alkaline ſalts have as yet been diſcovered.

§ CXXV. *Species of metallic ſalts.*

ANALOGICAL metallic ſalts are by far the moſt numerous. From a combination of the ſixteen metals with the twenty acids, we obtain three hundred and twenty double ſalts; but

but which can be ſcarcely ſo perfectly ſaturated, as that there ſhould not be ſome ſmall exceſs of acid.

§ CXXVI. *Metallic Salts, with an Exceſs of the metallic Baſe.*

THERE are ſome inſtances alſo of the union of metals and acids, highly deſerving of notice, in which the exceſs is on the part of the metal. To this head we refer the turpith mineral, and red precipitate of Mercury, which though ever ſo well waſhed, yield a ſmall quantity of acid on diſtillation. The ſame remark applies equally well to the pulvis algarothi. Mercurius dulcis retains its metal partly calcined and partly perfect *; and nitrated ſilver, in like manner can take up a portion of ſilver, without dephlogiſticating it. Muriated copper, deficient in its acid, conſtitutes a peculiar ſalt hitherto undiſcribed.

§ CXXVII. *Triple metallic Salts.*

WE have long been acquainted with a conſiderable number of metallic triple ſalts, that are not ſeparable but by decompoſition. Of this deſcription are the combinations of tartar with iron and antimony; of the vitriolated vegetable

* Scheele in Actis Stockh.

getable alkali with iron; of the muriated vegetable alkali with platinum; of the vitriolated volatile alkali with copper; of the muriated volatile alkali with platinum, quickſilver, copper, and iron; of vitriolated and acetated quickſilver with iron; of vitriolated iron with magneſium, with copper, and with zinc.

§ CXXVIII. *Quadruple metallic Salts.*

THE quadruple metallic ſalts are formed by the union of ſal ammoniac with nitrated iron, with nitrated copper, and with boracic quickſilver; of the vitriol of iron, likewiſe, with the vitriols of copper and zinc together.

§ CXXIX. *Alkaline metallic Salts.*

MOST of the alkalis alſo combine readily with metals, eſpecially the volatile alkali; which ſometimes forms beautiful cryſtals, with a metallic baſe, as with ſilver and copper. The numerous family of theſe ſalts are deſerving of much greater attention than has ever yet been paid to them.

§ CXXX. *Synopſis of Salts.*

FROM what has been ſaid, I am of opinion there can be no doubt of the extenſive influence and

and variety of the claſs of ſalts, in which we have here conſidered all thoſe prepared by art, as well as thoſe produced by nature. In favour of the halurgic ſyſtem, I ſhall ſubjoin a table, preſenting at one view all the chief varieties, with which I am acquainted. A greater number of proper experiments would certainly add many more to the account.

SALTS.

- Properly ſo called
  - Simple
    - Acid
    - Alkali.
  - Double
    - Neutral
    - Imperfect.
  - Triple
    - Neutral
    - Imperfect.
  - Quadruple
    - Neutral
    - Imperfect.
- Analogic
  - earthy
    - with an acid
      - double
      - triple
        - Perfect
        - Imperfect
    - with an alkali double
  - metallic
    - with an acid
      - double
        - Imperf. with excefs of acid
      - triple
        - Imperf. by defect of acid.
      - quadruple
    - with an alkali double

§ cxxxi.

§ CXXXI. *Species of Earths of a double Character.*

In the claſs of earths different ſpecies frequently occur, poſſeſſing two characters. To the firſt belong the ſaline earths; which, on account of the limits before aſſigned to them, are not reckoned in the claſs of ſalts, although they reſemble them in their nature, and conſtitute but an imperfect ſpecies of earths. Of theſe ſubſtances, however, a few only are known, § 51.

§ CXXXII. *Mixed Species of Earths.*

GENUINE ſpecies of mixed earths are produced by the intimate union of two or more. Of the exiſtence of ſuch an union we have clear evidence, in § 90.

§ CXXXIII. *On what Arguments their Diverſity is founded.*

Not the quality and number only of the ingredients, but even their relative weights imply a ſpecific diverſity.

§ CXXXIV. *The Neceſſity of conſidering the Proportion of every Part.*

IN the Sciagraphia Regni Mineralis, lately publiſhed

publiſhed, I have overlooked the mutual proportions; but, on further reflection, I find the conſideration of them abſolutely neceſſary.

§ CXXXV. *Method of inveſtigating the ſeveral Species of Earths.*

In order to determine with accuracy the ſpecies of earths, which hitherto ſeem to have reſted on no very certain foundation, it will be requiſite to explain carefully this doctrine. Let the five primitive earths be indicated by five initial letters, the ponderous by *p*, calcareous by *c*, magneſian by *m*, argillaceous by *a*, and ſiliceous by *s*.

§ CXXXVI. *Continuation.*

At firſt we will attend to the character only and number of principles; and, by means of the doctrine of combinations, it will be eaſy to aſcertain how many ſpecific conſociations can ariſe from theſe five letters.

For example, *p*, *c*, *m*, *a*, and *s*, can produce no more than ten double ſpecies—

pc, *pm*, *pa*, *ps*,
cm, *ca*, *cs*,
ma, *ms*,
as.

Of

Of triple ſpecies we have as follows:—

pcm, *pca*, *pcs*, *pma*, *pms*, *pas*,
cma, *cms*, *cas*,
mas.

Quadruple:—

pcma, *pcms*, *pcas*, *pmas*.

Laſtly, One quintuple only:—

pcmas.

In this manner, from the whole claſs of earths, beſides the five ſimple ſpecies, containing the primitives alone, we can obtain but twenty-ſix different combinations; which, together with the five ſimple, amount in all to thirty-one.

§ CXXXVII. *Why this Method is imperfect.*

In this plan, however, the number of the ſpecies is too much limited, and our concluſions liable to error. It will eaſily appear that *pa*, for example, muſt be ſeparated; for the character of the maſs, with an exceſs of ponderous earth, will be by no means the ſame as with an exceſs of clay. In like manner *pac* ſhould be referred to three diſtinct genera, according as the firſt, the ſecond, or the third principle bear the greateſt ſhare in the compoſition, (§ 78.). The ſame, indeed

indeed, will be obſerved in whatever formula is employed. Therefore it is neceſſary, together with the number of the principles, to conſider the weight of each.

§ CXXXVIII. *In what Manner can this Defect be ſupplied or corrected.*

THAT they may be all ſymbolically deſigned, and rendered obvious to the ſenſes, a certain local value muſt be aſſigned to every letter; ſo that whatever principle occurs firſt in combination, that ſhould be underſtood to be the heavieſt of the whole maſs: Every intermediate principle will yield to the preceding one, but exceed thoſe that follow it, and the laſt of all will be of the leaſt importance.

§ CXXXIX. *Enumeration of double Species.*

ACCORDING to this ſyſtem then we ſhall have twenty double ſpecies:

pc,	*pm*,	*pa*,	*ps*.
cp,	*cm*,	*ca*,	*cs*.
mp,	*mc*,	*ma*,	*ms*.
ap,	*ac*,	*am*,	*as*.
ſp,	*ſc*,	*ſm*,	*ſa*.

§ CXL. *Enumeration of triple Species.*

EACH of the five letters in forming triple compoſitions, may be arranged in twelve different ways. Five multiplied by twelve, therefore produce ſixty ſpecies as follows:

pcm, pca, pcſ, pma, pmſ, pmc, paſ, pac, pam, pſc, pſm, pſa.
cpm, cpa, cpſ, cmp, cma, cmſ, cap, cam, caſ, cſp, cſm, cſa.
mpc, mpa, mpſ, mcp, mca, mcſ, map, mac, maſ, mſp, mſc, mſa.
apc, apm, apſ, acp, acm, acſ, amp, amc, amſ, aſp, aſc, aſm.
ſpc, ſpm, ſpa, ſcp, ſcm, ſca, ſmp, ſmc, ſma, ſap, ſac, ſam.

§ CXLI. *Quadruple Species.*

AS the double ſpecies amount to twenty; and theſe, with the remaining three letters can be combined in ſix different ways, in the quadruple ſpecies, it will be eaſily ſeen, that ſix times twenty, or one hundred and twenty, will expreſs the amount of this diviſion.

pcma, pcam, pcmſ, pcſm, pcſa, pcaſ, pmac, pmca, pmaſ, pmſa, pmcſ, pmſc, pacm, pamc, pacſ, paſc, pamſ, paſm, pſcm, pſmc, pſac, pſca, pſam, pſma.

cpma, cpam, cpmſ, cpſm, cpaſ, cpſa, cmpa, cmap, cmpſ, cmſp, cmaſ, cmſa, capm, camp, capſ, caſp, camſ, caſm, cſpm, cſmp, cſpa, cſap, cſma, cſam.

mpca, mpac, mpaſ, mpſa, mpcſ, mpſc mcpa, mcap, mcpſ, mcſp, mcaſ, mcſa, macp, mapc, macſ, maſc, mapſ, maſp, mſcp, mſpc, mſap, mſpa, mſac, mſca.

apcm, apmc, apmſ, apſm, apcſ, apſc, acpm, acmp, acmſ, acſm, acpſ, acſp, ampc, amcp, ampſ, amſp, amcſ, amſc, aſpc, aſcp, aſpm, aſmp, aſcm, aſmc.

ſpcm, ſpmc, ſpam, ſpma, ſpca, ſpac, ſcpm, ſcmp, ſcam, ſcma, ſcpa, ſcap, ſmca, ſmac, ſmpa, ſmap, ſmcp, ſmpc, ſapc, ſacp, ſacm, ſamc, ſamp, ſapm.

§ CXLII. *Quintuple Species.*

THE triple ſpecies being ſixty in number, (§ 140.) and each of theſe admitting of two changes only with the other two letters, it follows

lows, that, under this head, we may reckon one hundred and twenty ſpecies.

pcmaſ, pcmſa, pcamſ, pcaſm, pcſam, pcſma,
pmcſa, pmcaſ, pmaſc, pmacſ, pmſca, pmſac,
pamſc, pamcſ, paſmc, paſcm, pacſm, pacmſ,
pſcma, pſcam, pſmca, pſmac, pſamc, pſacm.

cpmaſ, cpmſa, cpaſm, cpamſ, cpſam, cpſma,
cmpaſ, cmpſa, cmapſ, cmaſp, cmſpa, cmſap,
camſp, campſ, capmſ, capſm, caſpm, caſmp,
cſmpa, cſmap, cſpma, cſpam, cſapm, cſamp.

mpcſa, mpcaſ, mpacſ, mpaſc, mpſca, mpſac,
mcpaſ, mcpſa, mcapſ, mcaſp, mcſpa, mcſap,
mapcſ, mapſc, macpſ, macſp, maſcp, maſpc,
mſpca, mſpac, mſcap, mſcpa, mſacp, mſapc.

apcmſ, apcſm, apmcſ, apmſc, apſcm, apſmc,
acpmſ, acpſm, acmpſ, acmſp, acſpm, acſmp,
ampcſ, ampſc, amcpſ, amcſp, amſpc, amſcp,
aſpcm, aſpmc, aſcpm, aſcmp, aſmpc, aſmcp.

ſpcma, ſpcam, ſpmca, ſpmac, ſpacm, ſpamc,
ſcpma, ſcpam, ſcmpa, ſcmap, ſcamp, ſcapm,
ſmpca, ſmpac, ſmcpa, ſmcap, ſmacp, ſmapc,
ſapcm, ſapmc, ſacpm, ſacmp, ſampc, ſamcp.

§ CXLIII. *Amount of the Species.*

IF the primitive earths are five in number, then the preceding paragraphs exhibit the formulæ of all thoſe ſpecies that can poſſibly ariſe from their various combination; and to which, adding the five ſimple earths, we ſhall find the amount to be thus, $5+20+60+120+120=325$, the amount of the whole.

§ CXLIV. *Further Explanation of the Formulæ.*

I HAVE ſo contrived theſe formulæ as to make it evident to what genus every combination is to be referred.—The firſt letter determines the character of that genus, *s* only excepted; as, though it exceeds in weight, yet its other qualities do not always prevail, (§ 89.)

If at any time the number of the primitive earths is diminiſhed, whether by decompoſing them into others more ſimple, or by diſcovering them to be of a metallic nature, yet the ſame formulæ may be preſerved after making the neceſſary correction.

For example, Suppoſe *p* were referred to the third claſs, the quintuple formulæ, (§ 142.) would then become quadruple, that ſeries being deſtroyed entirely where *p* begins, and from all the others would it be taken away. In this caſe, we

we loſe the whole of the firſt genus, and the ſame formulæ are repeated four times in each of the remaining genera, and conſtitute one ſpecies only; ſo that $\frac{24}{4}=6$ ſpecies is of each genus and $4\times6=24$ the number of all the quadruple ſpecies.

Let us take another example, and remove altogether *a*, the formulæ of that genus are immediately annihilated, and the eighteen in the three other genera are reduced to $2\times3=6$.

In the ſame manner, that the corrections are made in the formulæ of the laſt order, can they be applied to thoſe preceding. For it is evident that in reducing quadruple to triple ſpecies, it is impoſſible when *p* is deſtroyed, that the remaining ſeries ſhould be quadruple, and are therefore to be removed entirely.

Let *n* repreſent the number of primitive earths, and the number of the double ſpecies be expreſſed by *n*. *n*—1. of triple ſpecies by *n*. *n*—1. *n*—2, of quadruple ſpecies by *n*. *n*—1. *n*—2. *n*—3, and that of the laſt order by *n*. *n*—1. *n*—2.—*n*—*n*—2.

§ CXLV. *Species of Metals.*

HAVING determined theſe points, we now proceed to the third claſs, in which, on account of the greater number of genera, we ſhall find the ſpecies alſo to be far more numerous.

Metals occur generally either complete, mineralized, or deprived of their phlogiſton.

§ CXLVI. *Native Metals.*

WHATEVER poſſeſſes a complete metallic form, is denominated native.

Into this ſtate no heterogeneous ſubſtances are admitted, unleſs they are perfectly metallic. Hence ariſe various ſpecies;—the metal native and ſimple;—combined with ſome other;—or with ſeveral together. Native ſimple metals are very rare, and, as far as I know, have never yet been diſcovered perfectly pure.

Moſt metals are occaſionally found native, as gold, platinum, ſilver, quick-ſilver, copper, biſmuth, niccolum, arſenic, cobalt, and antimony; but ſcarce any one of them occurs quite pure. Gold is mixed with ſilver or copper; ſilver with gold or copper; platinum with iron; niccolum and cobalt with arſenic as well as iron; antimony with iron or zinc; and further experiments will without doubt diſcover other combinations.

The exiſtence of native lead, iron tin, and zinc has been always much queſtioned by many.

Magneſium and ſiderite have never yet been found in a native ſtate.

§ CVLVII.

§ CXLVII. *Mineralised Metals.*

A MINERALISED metal appears to me to be a metal intimately united with some foreign substance that destroys more or less the genuine metallic form.

§ CXLVIII. *Mineralising Substances*

SUCH are sulpher and acids.

CXLIX. *Metals mineralised by Sulphur.*

SULPHUR can be directly united with all the metals, except gold, platinum, and zinc; and these mineralisations are found in the bowels of the earth. Sulphurated tin also occurs in Siberia *.

Some mineralizations are affected, both as to character and appearance, according to the quantity of sulphur. Tin, combined with twenty hundred parts of sulphur, forms a mineralisation, white and fibrous; but, with twice that proportion, the compound is micaceous, and of the colour of gold.

Sulphur acting on perfect metals separates a portion of their phlogiston; and is even capable of uniting with many calces likewise.

* Essays, vol. iii. p. 158.

The combination of gold with ſulphur, by the intermedium of iron; is not yet made ſufficiently evident; for that which is found in pyrites ſeems to be rather mixed than diſſolved; as in a ſolution of pyrites, in the nitrous acid, the gold is depoſited in molecules, not in powder, but differing from each other both in ſize and figure *.

As to zinc, that metal appears in the pſeudo galena to be joined † with ſulphur by means of iron.

§ CL. *Mineraliſing Acids.*

OF mineraliſing acids there are ſeveral, as the vitriolic, muriatic, phoſphoric, aerial, and probably the arſenical.

§ CLI. *Vitriols.*

VITRIOLS of copper, iron, and zinc, are the ſpontaneous productions of nature. Combinations of the ſame acid with lead, niccolum, and cobalt, are likewiſe ſometimes found; and they ſeem generally to be the reſult of decompoſed mineraliſations.

§ CLII.

* Eſſays, vol. ii. p. 412.
† Ibid. p. 329, and 336.

§ CLII. *Metals mineraliſed by the Muriatic Acid.*

THE muriatic acid is more rarely found united with metals. As yet it has not been diſcovered in any other than ſilver, quickſilver, and copper. The two firſt contain with it the vitriolic acid likewiſe *.

§ CLIII. *Metals mineraliſed by the Aerial Acid.*

THE aerial acid is often preſent in calciform metals. We meet with it in lead, copper, iron, and zinc. Of its connexion with other metals we have no certain intelligence.

§ CLIV. *Metals mineraliſed by the Phoſphoric Acid.*

OF all the acids, that of phoſphorus is the ſcarceſt, and has hitherto been found with a ſpataceous kind of lead only.

§ CLV. *Metals mineraliſed by the Arſenical Acid.*

THE arſenical acid, if I miſtake not, is the true menſtruum of the red cobalt, that is ſometimes beautifully cryſtalliſed. It is certain, that a red colour is owing to an acid, and that, from all the experiments as yet made, no other has been diſcovered.

§ CLVI.

* Woulfe, Philoſ. Tranſ.

§ CLVI. *The different Species of Metals admit of almoſt numberleſs Variations.*

WHOEVER conſiders, that we are acquainted already with ſixteen metals, and that of theſe the greater number of the perfect can be in ſeveral ways combined together, as well as thoſe mineraliſed by ſulphur and various acids, will naturally expect that, by means of accurate analyſes, many more ſpecies might be diſcovered, which have as yet probably eſcaped the reſearches of the laborious philoſopher. Were we to purſue the plan applied to the earths, (§ cxliii.) the number would be really aſtoniſhing; but I am almoſt of Pliny's opinion, who ſomewhere confeſſes: "Mihi contuenti ſeſe perſuaſit re-"rum natura nihil incredibile exiſtimare de ea." Formulæ, indeed, point out to us what may be done; but whether, and where, they are employed, muſt be learned from a faithful analyſis; which aſſiſts us, beſides, better to underſtand thoſe of them that preſcribe the true limits to our inveſtigations.

§ CLVII. *Spiecies of Phlogiſtic Subſtances.*

THE fourth claſs is exceedingly poor both in genera and ſpecies.

§ CLVIII.

§ CLVIII. *Species of the Diamond.*

WE are acquainted with many differences of the diamond, but with none that are ſpecific.

§ CLIX. *Species of Sulphur.*

THE ſpecies of ſulphur are diſtinguiſhed by the diverſity of their acids, and we know of two only; the common formed by the vitriolic acid, and plumbago, containing the aerial acid ſaturated with phlogiſton.

§ CLX. *Species of Petroleum.*

THE varieties of petroleum, in colour and tenuity, depend for the moſt part on the degree of exſiccation, and on the matrix or heterogeneous ſubſtances mechanically mixed with it; ſo that they can be conſidered but ſeldom as ſpecific. Exſiccation produces a maſs thick and tough, or ſolid and dry.

§ CLXI. *Amber.*

THE ſame obſervations nearly will apply to amber. In reſpect of tranſparency and colour, we meet with many varieties in the European ſpecies.

The

The Indian ſpecies agrees in all thing with the European, except its being ſofter, and wanting the volatile ſalt*, which laſt circumſtance ſeems to eſtabliſh a ſpecific difference. Copal, commonly ſo called, is to be diſtinguiſhed from the gum reſin of that name ſold by the apothecaries.

§ CLXII. *Origin of Phlogiſtic Subſtances.*

DIFFERENT opinions are maintained by philoſophers, reſpecting the origin of phlogiſtic ſubſtances. Some contend, that theſe bodies are proper to the foſſil kingdom; while others, probably with more reaſon, aſcribe them to thoſe organic ſubſtances which abound in various oily and fat juices, and are not ſo much affected by time, as they are gradually changed in the bowels of the earth by neighbouring pyrites and other foſſils, until they acquire a bituminous quality. Heterogeneous ſubſtances encloſed within them are evident proofs of original fluidity. The different degrees of purity of naptha, coagulation performed by time, acids, or other media, and various circumſtances beſides in the great laboratory of nature, all influence the denſity, colour, clearneſs and other properties.

As to ambergriſe, Aublet inſiſts, that it is the juice of a tree growing in Guiana, and there called

* Lehman, Chem. Schrift.

called Cuina. He says, that after heavy rains, large masses of it are washed into the rivers. The specimens examined by Rosselle are said to resemble ambergrise in their odor and principle qualities *. Long ago, Rumphus makes mention of a tree called nanarius, containing a juice similar to ambergrise. Lately, however, in England an opinion has obtained, that this substance is the excrement of a cetaceous fish. Observations made on the physeter macrocephalus, (the spermaceti whale) have given rise to this Idea, as the excrement in the intestines of that animal, is found on dissection perfectly hardened, and containing the beak of the repia octopodia, on which it feeds, and in every respect resembling the ambergrise of commerce.

§ CLXIII. *Species of Fossils mixed mechanically.*

Of fossils mechanically mixed, that fall under consideration in the first appendix, we have constituted four genera only, (§ 91.) their species, however, are numerous.

§ CLXIV. *The several Species expressed by the Formulæ of Letters.*

Let *s* denote salt, *t* earth, *m* metals, and *i* phlogistic substances; and let the same local value

* Hist. des plantes de la Guyane, 1774.

value be aſſigned to theſe letters as in the foregoing examples, (§ 138.) and we ſhall obtain the following double ſpecies.

st, *sm*, *si*.
ts, *tm*, *ti*,
ms, *mt*, *mi*.
is, *it*, *im*.

Triple ſpecies.

stm, *sti*, *smt*, *sit*, *smi*, *sim*,
tsm, *tsi*, *tms*, *tis*, *tmi*, *tim*,
mst, *msi*, *mts*, *mis*, *mti*, *mit*,
ism, *ist*, *ims*, *its*, *itm*, *imt*.

Quadruple ſpecies.

stmi, *stim*, *smti*, *smit*, *sitm*, *simt*,
tsmi, *tsim*, *tmsi*, *tmis*, *tims*, *tism*,
msti, *msit*, *mtis*, *mtsi*, *mits*, *mist*,
istm, *ismt*, *itsm*, *itms*, *imst*, *imts*.

§ CLXV. *Continuation.*

WE are, however, not raſhly to conclude that all the ſpecies are exhauſted in theſe formulæ; for every letter may be varied in many ways, according to the diverſity of the ſeveral ſpecies. For example, *t* can be multiplied more than 325 times, (§ 131, 143). *I*, indeed, preſents but

but few variations, and *s* likewiſe; as the number of the ſalts proper for theſe mixtures, is exceedingly limited; but *t* ſurpaſſes even *m*, (§ 156); ſo that we have here another occaſion of admiring the exhauſtible ſtories of nature.

§ CLXVI. *The Poſition and ſituation of mixed Foſſils.*

IT is by no means to be expected; that every ſpecies of theſe mixed foſſils, which to me appear to be *petræ*, ſhould be equal to the production of huge mountains. The greateſt number of them have hitherto been found in veins or ſmall ſtrata only; many of which, though of different characters, when combined, give birth to rocks. The ſame may be ſaid of the ſeparate particles, which, in the aggregate, form large and continued ridges of hills. But theſe almoſt always ſpring from the ruins and decompoſitions of mountains.

§ CLXVII. *Species of organic Foſſils.*

ORGANIC foſſils conſtitute four genera, (§ 97.); but the ſeveral ſpecies of foſſils, whether poſſeſſing an organic form only, or with it an organic ſtructure, are diſtinguiſhed by ſpecific marks.

§ CLXVIII.

§ CLXVIII. *Species of organic Foſſils mineraliſed by Salts.*

ORGANIC foſſils, penetrated with ſaline matter, are but ſeldom found. Gypſum, indeed, ſometimes contains the leſs periſhable remains of animals and vegetables; but theſe ſubſtances are ſcarce ever found quite gypſeous. Entire animals are occaſionaly to be met, filled with vitriol, (§ 99.) and ſtill oftener the harder parts of vegetables, or their roots, ſeem to reſiſt putrifaction by the means of this ſalt.

§ CLXIX. *Earths.*

THE ſecond genus, comprehending earthy foſſils, is by far the richeſt. Innumerable calcareous nuclei of ſhell fiſh and marine inſects daily occur in calcareous ſtrata. Sometimes, an animal covering, or ſhell, which was before calcareous, being changed in its internal texture only, become ſpataceous.

Argillaceous nuclei of marine animals are common in aluminous ſchiſtus, but very rare in any other bed. Frequently the covering of the animalcule ſtill remains.

Marine exuviæ are obvious in marle alſo. If lime predominates, often the ſkeletons alone of the fiſh are ſeen. Of Oſteocolla we have already ſpoken ſufficiently, § 105.

Siliceous

Siliceous nuclei frequently fill entirely the internal cavity of organic foſſils, and ſometimes even the ſame matter ſurrounds their external ſurface. I am in poſſeſſion of an echnites, the ſhell of which is filled with common flint, and ſhews upon the ſurface of the nucleus all its natural inequalities; the ſhell itſelf, however is calcareous and ſpataceous, although it was imbeded in ſiliceous earth on both ſides. Small ſhells occur ſometimes in jaſper, but very rarely *, and are not more frequent in petroſilex.

Organic bodies, themſelves alſo are found penetrated with ſiliceous matter. Siliceous petrefactions of the trunks of trees are often diſtinctly marked with the growth of every year. Siliceous muſcles and cockles alſo frequently occur, and ſmall corals even are ſometimes clearly to be diſtinguiſhed in common flints.

I have ſeen the marks of leaves accurately expreſſed in quartz, and the epitomium of Blankenburg is often quartoſe.

Nuclei of ſand are ſometimes to be met with; but the figure of their ſurface is generally ſo obſcure, that it is very difficult to determine from what organic body they were produced.

In the ſand pit at Maeſtricht was found not long ago the ſkeleton of a crocodile, ſome teeth of which were ſent to me.

* Ferber in Epiſt. de Italia.

§ CLXX. *Species of organic Foſſils impregnated with metallic Particles.*

VERY few metals aſſume an organic form. The calx of iron, but ſlightly cohering, or concreted like a ſtone, penetrates roots, wood, and even whole trees, preſerving ſtill the fibrous texture, which may ſometimes be ſcraped with the nail.

Pyrotaceous iron, indeed, now and then forms nuclei; but it commonly adorns the organic ſtructure with lines or little ſpots, and ſeldom occupies it entirely.

Copper, in the form of a calx is ſuppoſed frequently to enter into bones and teeth, giving them a blue colour, eſpecially after they are calcined. This colour, however, is often owing to iron.

Pyritaceous copper alſo reſembles the anomia in the magnet of Iarliberg in Norway, and fiſhes in ſeveral places.

Spots of native gold or ſilver are ſometimes ſeen on the ſurface of foſſil ſhells.

The grey ore of ſilver at Frankenthal in Heſſe is found in the form of ears of corn, and commonly called *kohrn-ahren*; and under the appearance of leaves and ſtalks of ſome graniferous vegetable.

Cinnabarine ſhells are exceedingly rare.

I have in my poſſeſſion ſome pſeudogalena of a blackiſh yellow, united to millepores.

§ CLXXI. *Species of Phlogiſticated organic Foſſils.*

WOOD impregnated with petroleum frequently occurs. There is a trunk of a tree in the collection of the academy at Upſal, indurated with petroleum, black and ſmooth, and yet eaſily diſtinguiſhed to be of a beech. The Icelandic foſſil wood alſo comes under this head, of which I have ſpoken more fully in another place *.

Bones penetrated with aſphaltus are ſometimes found.

As is foſſil wood likewiſe, whoſe pores are filled with amber, and even with inſects and other ſmall animals; which this ſubſtance does not only penetrate, but even ſurrounds, as a ſplendid monument covering their remains.

Turf and mould contain organic bodies, eſpecially of vegetables reduced in the greateſt part by putrefaction to duſt; but which diſplay ſigns of their original ſtructure and character, more or leſs obſcure. The firſt ſcarce differs from the latter but in the greater decompoſition and denſity of its maſs.

* Eſſays, v. iii. p. 239

VARIETIES.

§ CLXXII. *Ordinary Confuſion of Varieties with Species.*

THAT many varieties have been obſerved in ſpecies properly determined is the more evident, as they have, for the moſt part, been conſidered as different ſpecies. A miſtake to which the practice of the mineralogiſts in determining ſpecific differences from external marks undoubtedly gave riſe.

§ CLXXIII. *Criteria of Varieties to be taken from external Appearances.*

IN the foregoing, we have ſhewn that ſpecific marks were to be taken from the particular compoſition; but although ſuperficial criteria do not affect the intimate nature of theſe bodies, yet they are not by any means to be neglected; they are well calculated to determine varieties, and are even uſeful, not only in leading often a ſkillful eye to proper diacritic experiments, but in throwing light upon the mode of production, and other intereſting circumſtances.

§ CLXXIV. *Illuſtration of external Marks.*

THE chief external marks are thoſe taken from the form of the outward ſurface; the texture, in the appearance of its particles by a recent fracture; the colour, hardneſs, and gravity.

§ CLXXV. *Amorphous Foſſils.*

FOSSILS that have no determined ſhape are denominated amorphous.

§. CLXXVI. *Chryſtalline Foſſils.*

BUT thoſe whoſe circumference is included within plain ſides meeting each other at various angles are called cryſtalline.

In the foſſil kingdom, we have five regular geometric figures, of plain, equal, and ſimilar ſides; as the tetraedra, cubes, octaedra, dodecaedra, and icoſaedra; beſides many others diſtinguiſhed by their priſmatic columns and pyramidal terminations. In what manner the great number of derivatives ariſe from a few primatives, and differing from each other at the firſt view, I have related elſewhere *.

Salts, indeed, on account of their ſolubility

* Eſſays, vol. ii. p. 1.

in water, more readily acquire a ſubtilety and freedom of their particles, which, through the means of attraction, is neceſſary to form them into cryſtalline concretions; but this property is not limited to them, as cryſtalline foſſils are found in almoſt every genus of earths, metallic, and phlogiſtic ſubſtances.

§ CLXXVII. *External Marks taken from the Texture of Foſſils.*

THE texture of foſſils is not eaſily determined by the form of the particles; as when they are intimately combined with each other they are always mutilated by fractures; we may, however, diſtinguiſh many varieties. The moſt ſubtile ſhapeleſs molecules uſually called impalpable, give riſe to an equal texture: while others larger, and more diſcernable produce a granous, filamentous, ſcaly, and ſpataceous compoſition.

§ CLXXVIII. *From the Colour.*

COLOURS, eſpecially the gradual ſhades of them, can ſcarce be ſo deſcribed by language, as to convey any clear idea, Hardly any other method, therefore, than that of compariſon can be uſed by always referring to thoſe colours ſufficiently underſtood.

§ CLXXIX.

§ CLXXIX. *Physical Marks.*

PHYSICAL marks also, as hardness and gravity, are to be employed for ascertaining varieties, whenever they are found to throw any light.

§ CLXXX. *Varieties of organic Fossils.*

THE varieties of organic fossils are to be determined from the species of vegetables or animals, which serve as guides to our judgement. And all living bodies being defined by their external appearance, the same rule may be observed in this as in the other classes.

§ CLXXXI. *Epilogue.*

A SYSTEM of fossils, arranged according to the foregoing method, I think is to be recommended for its variety, order, and utility; for the number of species and varieties, the manyfold combinations of principles, the series of agreement and discrepancy, the harmony and opposition of internal and external characters, and many other important reasons: And I hope it will be found to answer better, not only on account of its extensive view, but also because the riches and phenomena of the organic kingdoms are in it more properly displayed than in any other.

LATTER PART.

Of giving Names to Fossils.

§ clxxxii. *The Utility of Names properly adapted in Mineralogy.*

If foſſils are rightly and juſtly arranged and denominated, agreeably to the nature of things, we find a harmony in them not leſs grateful than advantageous.

§ clxxxiii. *Hiſtory of Names in Natural Philoſophy.*

The ſciences cultivated during the early ages, as chemiſtry, and all thoſe depending on it, had unhappily adopted certain ſchemes and modes of ſpeech, of which the greater part were not only puerile and abſurd, but often altogether falſe, and leading to erroneous concluſions. Many circumſtances contributed to the ſupport of this mummery. At firſt, in thoſe days of darkeſt ignorance, names were required to deſcribe new diſcoveries and phenomena, adapted to the unſkilfulneſs of their authors. By degrees the knowledge of natural bodies, as well as of artificial, being extended, the profeſſors of chemiſtry began to entertain ſuch lofty ideas of their

their ſkill, that they did not heſitate to promiſe themſelves the miracles of an univerſal medicine, and the making of gold. Hence aroſe the ridiculous ſtruggle betwixt the immoderate boaſtings, through which they were endeavouring to diſpoſe advantageouſly of their diſcoveries, and the moſt ſolicitous attention with which they wiſhed to keep them concealed. What the names they employed could be, when depending on the moſt abſurd theories, the ſlighteſt appearances, and moſt abſtruſe metaphors, we are at no loſs to apprehend. To theſe were added afterwards others produced by any fortuitous ſlight occurrence; and we perceive in ſome meaſure a language peculiar to the early operations of chemiſtry.

§ CLXXXIV. *Of reforming the Names of Foſſils.*

THE inſtitution of academies of ſcience gave riſe to the gradual introduction of a ſounder theory, founded upon more accurate experiment, which tended conſiderably to limit the barbarous and myſtical affectation of ſecrets; and occaſioned a more rational denomination of new diſcoveries, though as yet not built upon general principles. Beſides, the rude and indigeſted maſs of antiquity was ſtill preſerved for the greateſt part, and chiefly for the following reaſons. From the reformation of names and phraſes

phraſes, it was apprehended that the whole ſcience would be involved in great confuſion, and that their number would create conſiderable difficulties; and it was likewiſe alledged, that the moſt ancient writings would, by this means, be rendered unintelligible, and all the ſcience they contained condemned to oblivion. But ſuch evils, at leaſt not all of them, ſeem not to be a neceſſary conſequence. The oldeſt writings, eſpecially thoſe on alchemy, are almoſt all of them incomprehenſible: Whatever therefore will anſwer to probable conjecture, or will admit of a certain and determinate explication, might be more eaſily underſtood, if tranſpoſed according to the nature of the ſubject,—and the ſenſe of this or that denomination being once extracted, it might be preſerved in a book appropriated to the purpoſe. As to what relates to the dread of the introduction of new names, it would undoubtedly be well grounded were not all writers to ſuffer them to be regulated in the ſame manner. In this caſe the new names adapted to the nature of things would readily inſinuate themſelves, and be univerſally received.

Surely, it is highly improper that the nobleſt ſcience, which conſtitutes, as it were, the very eſſence of natural philoſophy, ſhould deliver truths of the greateſt importance in the moſt abſurd of all languages. Every country in Europe

rope has thought the cultivation and perfection of its peculiar language an object highly worthy of attention; and ſhall the ſciences alone be diſtinguiſhed for rudeneſs and barbarity of ſtile, while they are daily requiring new names to expreſs new diſcoveries conſtructed upon rational principles; and which, if they are not all wiſely and methodically ordered, would ſometimes by their number occaſion the deſtruction of thoſe very diſcoveries they were intended to preſerve. In botany, ſuch a reformation has long taken place; and what is there that ſhould prevent ſo ſalutary a plan from being extended to the other ſciences?

But notwithſtanding the obvious neceſſity of reform, as well as of ſome fixed ſtandard, according to which all the new names ſhould be regulated, there are ſtill many difficulties that oppoſe their free introduction into the republic of letters. From the very nature of the propoſal it is expoſed to the influence of particular opinions; and every one, partial to his own, and chuſing different data, it will be impoſſible in the beginning at leaſt, to unite, in one common conſent, ſentiments ſo adverſe and contradictory. We are not however to deſpair; for, if the voices of all do not combine, perhaps the greater number will, to ſtifle the clamour of perſiſting cavillers. Every real friend to chemiſtry, therefore, ſhould wiſh for a happy iſſue to the

the plan of Monſ. Morveau, to be attempted in the new Encyclopædia. In the mean time, it may be permitted me to offer a few curſory remarks, which I think are relating particularly to mineralogy, and ſubmit them to the judgement of the public. The end of the whole ſyſtem is doubtleſs to expreſs with truth, perſpicuity, preciſion, and brevity, every thing of which an idea can be conveyed by words. New names, therefore, become neceſſary to new things; and to render theſe the moſt convenient is the chief aim and object of this undertaking.

§ CLXXXV. *Names that are evidently abſurd, and ought to be expunged.*

I AM of opinion, that all abſurd names, and ſuch as betray oſtentatious vanity, are to be entirely ſet aſide. Of theſe we have examples in the ſal mirabile Glauberi, ſal ſecretum Glauberi, ſal polychreſtum Glaſeri, arcanum corralinum, arcanum duplicatum, ſal de duobus, and ſeveral others.

§ CLXXXVI. *And falſe Names likewiſe.*

IN like manner, names that are falſe ought to be removed. Of this deſcription are the following, ſuggeſting ideas that are erroneous:

Oleum

Oleum vitrioli	For	Concentrated vitriolic acid.
Spiritus vitrioli		Diluted vitriolic acid. Spirit indicates properly an inflammable liquor miſcible with water.
Oleum tartari		Vegetable alkali diſſolved by deliqueſcence.
Sal tartari		Alkali of tartar.
Terra foliata tartari		Acetous acid ſaturated with the vegetable alkali.
Butyrum antimonii		Muriatic acid ſaturated with antimony.
Semi-metallum		Fragile metal.

§ CLXXXVII. *What then are the names to be adopted?*

THOSE names which indicate ſome eſſential property or compoſition are of all others the beſt.

§ CLXXXVIII. *What are the Names to be tolerated?*

THOSE which admit a more extenſive ſignification may be ſuffered, if others evidently better cannot be ſubſtituted. And theſe indeed are

are true names; for although, from the power of the words, they will apply to many ſubſtances, nothing prevents them from being κατ' ἐξοχην applied to the one or the other. In this way acidum aerium was uſed in the year 1772, for aer fixum; which is not abſolutely advancing a falſehood, as it poſſeſſes a proper acid, and in an aerial form; but it is objectionable, becauſe theſe qualities are diſcoverable in other ſubſtances. Let therefore ſome other denomination be ſubſtituted more exact and determinate, as, gas, or acidum mephiticum, or elſe there will be no end to the various changes. But if it be impoſſible to find one more accurate, it will be attended but with little inconvenience, to apply it to that ſubſtance which we know for certain to be the acidum aerium of the antients.

§ CLXXXIX. *Names ſignifying leſs than the Thing defined ought to be aboliſhed.*

WHATEVER names expreſs too limited a ſenſe ſhould certainly be expunged, if a choice can be made among thoſe that are ſynonimous, eſpecially thoſe recommended by long time; as they convey falſe and inadequate ideas. Thus *mineral* indicates properly an ore; but in the vulgar ſenſe it ſignifies every inorganic body found in the boſom of the earth; although this idea is more accurately expreſſed by the word *foſſil*.

In

In like manner, *oryctologia* implies a more exact denomination of the ſcience of foſſils than *mineralogia*. *Petrefactum* or *petrificatum*, falls nearly under the ſame criticiſm. But as here we have no better ſynonimous word to ſubſtitute, we muſt be contented with ſuch as cuſtom has eſtabliſhed. Words, like coin, owe their currency to preſcription.

§ CXC. *How we are to proceed without proper emphatic Names.*

As it is not eaſy to apply names exactly expreſſive of the thing defined, we are to adopt ſuch as having no determinate meaning may have their ſenſe aſcertained by definition.

§ CXCI. *Names derived from the Authors of new Diſcoveries.*

AMONG botaniſts and anatomiſts the memory of diſcoverers is perpetuated in particular denominations; it may, therefore, be a queſtion, whether among chemiſts, where the reward of new facts is attended with greater inconvenience, it would be proper in the ſame manner to teſtify a grateful ſenſe of obligation? To me, indeed, it ſeems to be practicable, and without any impropriety; but as it often happens, that the ſame diſcovery has been made by different individuals

individuals at the ſame time, it might, upon the whole, be better to truſt the fame of all, to the impartial records of the hiſtoric page. This exception, however, need not extend to names of little importance in chemiſtry.

§ CXCII. *By what Means are the Claſſes of Foſſils to be defined?*

EACH claſs of foſſils ſhould, if poſſible, be defined by one ſingle word. Such as,—Salts, Earths, Metals, and Phlogiſtica. True, indeed, the laſt is an adjective; but on this account ſolely it is not to be rejected, as we ſhall preſently ſhew: Nor, indeed, have we reaſon to apprehend ambiguity from the uſe of it, as the context will always determine whenever it refers to foſſils. If any one ſhould think the word *bitumina* preferable, I can have no objections; although it may appear extraordinary to many to conſider diamonds under this definition.

For want of a more proper appellation, I diſtinguiſh foſſils mixed mechanically under the name of Petræ. My reaſons for this diſtinction I have given already in § 166. Thoſe, however, that form the ſubject of the other appendix, as organic foſſils, can ſcarce be defined under one title, and we muſt therefore either employ two, or call them in general Petrefactions, § 189.

§ CXCIII.

§ CXCIII. *Denomination of Genera.*

EACH genus ſhould be expreſſed in one word, for the ſake of brevity and convenience.

Among the ſalts there are, ſtrictly ſpeaking, but two genera; the acid and the alkali. And we ſhall ſee by and bye the great advantage this produces, that the combinations of every acid conſtitute proper genera. An acid may be conſidered ſubſtantively without the neceſſity of having the word Salt prefixed to it, as every acid is a ſalt.

In the ſecond claſs we have found five genera. One of which, but lately diſcovered, has, on account of its ſpecific gravity, obtained the name of Terra Ponderoſa. But in order to render it more conciſe and convenient, the firſt word might be eaſily omitted, though always underſtood, and the laſt employed alone as a ſubſtantive; or we would, with Monſ. de Morveau, adopt Barites from βαρυς with great advantage. The remaining earths are all expreſſed with ſubſtantive names; but for the ſake of perſpicuity, I would yet recommend ſome alteration in them: As for example, Calx, Magneſia, Argilla, and Silex, are deſcriptive of foſſils, ſuch as they occur on the ſurface of the earth, blended more or leſs with heterogeneous matter; and therefore the words Calcareum, Magneſium,

Argillaceum and Siliceum, might be properly uſed to ſignify theſe ſubſtances pure and unmixed.

The names of the ſixteen metals are all ſubſtantives, and except one, are of the neuter gender. The ὑδραργυρος of the Greeks was tranſlated into Latin by Pliny *hydrargyrum*, and why may not the *platina* of the Spaniards be adopted into the ſame language, with a neutral termination? According to this propoſal, we ſhall have the following generic names, *aurum*, *platinum*, *argentum*, *hydrargyrum*, *plumbum*, *cuprum*, *ferrum*, *ſtanneum*, *viſmutum*, *niccolum*, *arſenicum*, *cobaltum*, *zincum*, *antimonium*, *magneſium*, and *ſiderum*, if this laſt differs at all from iron. Each of them are to indicate the metal in its complete ſtate. Dephlogiſticated metals, commonly called calcined, or metallic calces, reſemble indeed, in ſome meaſure, burned chalk, from their attraction of the aerial acid, from their becoming cauſtic with the volatile alkali, their ſuſceptibility of pulveriſation, and other properties.

Of phlogiſtic bodies, the generic names are ſo well conſtructed that we have no remarks to offer upon them: *Adamas*, *ſulphur*, *petroleum*, and *ſuccinum*, are received with propriety.

The four genera of *petræ* I define by the following names. The firſt, abounding in ſaline matter, I call *ſalſamentum*; the ſecond, loaded with earthy matter, appears to me to be properly

ly *saxum*; the third, containing metals in their matrices, I denominate *minera*; and the fourth, from the mixture of petroleum, or other phlogistic bodies more plentifully found in it, takes the name of *bitumen*; or, if this name be given to a class, *picarium* may be substituted.

Of the organic fossils, that which is penetrated with any salt may be called *salitura*; with earthy particles, *lapidosum*; with metallic, *metalliferum*; and with phlogistic, *pollinctum*. Should names more proper than these occur to any person I shall have no objection to withdraw them.

§ CXCIV. *Of applying Names to the simpler Fossils, and especially to the Salts.*

All bodies, whose proximate principles have never yet been ascertained by art, require simpler names; the primitives especially should be expressed by one word; and those of a known composition should be defined by derivatives having a reference to their principles; if not of one or two words, consisting at the most of three. To denote each body by a peculiar simple name would be productive of great inconvenience, and be an useless burden to the memory. It might however be of considerable advantage to the system of nomenclature, in the class of salts, if every one of the simple salts could be indicated by a single word. Would it

not therefore be admiſſible, by ſuppoſing the acid to conſtruct the names as ſubſtantives? As for example, *vitriolicum*, *nitroſum*, *muriaticum*, *regalinum*, *fluoratum*, *arſenicale*, *boracinum*, *ſaccharinum*, *oxyalinum*, (inherent in the acid of the wood ſorrel) *tartarum*, *benzoinum*, *citrinum*, *ſuccineum*, *galacticum*, *formicale*, *ſebaceum*, *phoſphoreum*, and *aereum*. Phlogiſticated vitriolic acid might be named *ſulphureum*, and phlogiſticated nitrous acid *nitreum*. In like manner, in the genus of alkalies, the vegetable will be *potaſſinum*; the mineral *natrum*, a name by which it has ſometime been already known; and the volatile will be *ammoniacum*. The great advantage of this ſimplicity, as we ſhall ſee preſently, will be obvious in giving names to compounded ſubſtances; which, if they conſiſt of more than two or three words, will give riſe to a diffuſe and circuitous ſtile, both in ſpeaking and writing. All names certainly proceeding from the definition of ſeveral words are by far the moſt improper.

§ CXCV. *Names of Species demonſtrated in the Caſe of Salts.*

SPECIFIC differences, that can ſerve as diſtinct names, are uſed with conſiderable advantage. Admitting what has been already propoſed in the preceding paragraph, this very eaſily

ally obtains in the claſs of ſalts, as to all the ſpecies perfectly ſaturated. That earthy and metallic ſalts ought to be arranged under the head of their menſtrua, we have ſeen in § 70.; but, with reſpect to the perfect neutral ſalts, it is not ſo clear, § 68. It ſeems indeed more convenient to refer them to the genera of their ſeveral baſes; and in this way alſo I have proceeded. But we ſhall have more agreement with the analogical ſalts, moſt of which are properly aſſigned to the acid, if the neutral ſalts are ſubjected to the ſame arrangement. According to this method we ſhall have names ſufficiently apt by combining the acid with the adjective of the baſis. As for example,

Vitriolicum potaſſinatum, for Tartarus vitriolatum.
Nitroſum natratum, — Nitrum cubicum.
Muriaticum ammoniacum, — Sal ammoniacus.
Acetum potaſſinatum, — Terra foliata tartari.
Vitriolicum calcareatum, — Gypſum.
——— magneſiatum, — Sal catharticus amarus.
——— argillatum, — Alumen.
Nitroſum barytatum, — Barytes nitratus.
——— argillatum, — Calcareum nitratum.
Muriaticum barytatum, &c. — Barytes muriaticus.

Metallic double ſalts alſo may be treated in the ſame manner; as,

Vitriolicum auratum, &c.
Nitroſum argentatum, &c.
Muriaticum plumbatum, &c.
Arſenicale cobaltatum, &c.

and many others.

No one can object to thoſe adjectives derived from the names of the metals, as Pliny uſes the word *ferratum;* and it is according to this plan that they are here applied.

Analogical ſalts, containing an alkali, may be eaſily arranged in the ſame manner.

Thus,

Potaſſinum — { Argillatum, Silicatum, &c.

Ammoniacum — { Argentatum. Cupratum, Zincatum, &c.

Double ſalts, in which either principle prevails can alſo be denominated in ſuch a manner as to expreſs an imperfect ſaturation, § 127. For example,—Tartar, with an exceſs of acid, can be defined by a combination of its generic name with the genitive of its baſe, as *tartareum potaſſini;* but, when perfectly ſaturated, may be called *tartareum potaſſinatum.* In like manner we ſhall have *oxalinum potaſſini*, but, when exactly ſaturated, it will be *oxalinum potaſſinatum; vitriolicum natri*, and *vitriolicum natratum; natrum boracini*, and *boracinum natratum;* and ſo on of others.

This

This method, however, is not applicable in other classes, not even to the double species. Saline earths, with such an excess of earthy matter as nearly to obliterate their saline character, ought thus to be expressed.

Barytes vitriolatus, for Spatum ponderosum.
Calcareum fluoratum, — Fluor mineralis.
Calcareum aeratum, — Calcareum vulgare.

The character of the remaining fossils differs more considerably from the salts, and requires auxiliary illustration.

§ CXCVI. *Trivial Names of Salts.*

Fossils, containing three or more principles appear capable of the clearest definition by means of the trivial names. The celebrated Linnæus first made use of such, in his Species Plantarum of 1753, by which every species could be conveniently expressed, without a repetition of the specific differences. The language of botany became thus remarkably easy and intelligible; and zooligists and mineralogists have to thank the same author for the happy introduction of them into their sciences.—But, although these names may be assumed from the inventor, some virtue, ancient appellation, property, or accidental circumstance respecting the species; yet should they be generally limited to one word, and very seldom indeed extend to two. They may be considered as surnames dis-

tinguiſhing the individuals contained in the ſame genus.

The triple ſalts are, by means of theſe trivial names, denominated with great facility. Of which we have the following examples:

Vitriolicum fallax — Epſom ſalt united to the volatile alkali; eaſily producing an apparent inequality of attract.

——— epilepticum, — Epileptic ſalt of Weiſman.

Muriaticum anti-epilepticum, — Anti-epilepticum puerorum of Boerhaave.

——— alembrot, — Sal alembrot.

——— dulce, — Mercurius dulcis.

Galacticum Bartoleti, — Sugar of milk, firſt deſcribed by Bartoletus.

Tartarum Seignetti, — Sal polychreſtum Seignetti.

——— Laſonii, — Tartar joined to the ſedative ſalt.

——— ſolubile, — Tartar ſaturated with volatile alkali,—commonly called tartarus ſolubilis.

——— Mynſichti*, — Tartarus emeticus.

——— martiale — Globuli martiales.

Phoſphorum microſmicum, — Sal microcoſmicus.

Compound

* Eſſays, vol. i. p. 340.

Compound ſalts, produced by regalinum (aqua regis) never become triple, at leaſt not all of them. The nitrous acid ſeems to be neceſſary for the purpoſe of dephlogiſtication only; and the muriatic generally exhibits the ſame combinations as the regaline, by which, if the muriatic is not in ſufficient quantity, a double ſalt is obtained, charged with the nitrous acid,

The ſame obſervation is equally applicable to the quadruple ſalts.

Tartarum Fevri, — { Tartar united to borax,
Nitroſum Kunckelii, — Rubini Kunckelii.
——— ſympathicum, — { Sal ammoniac with nitrated copper.

This ſalt exhibits cryſtals, that aſſume a yellow colour when heated, but become blue in a moderate temperature. If a ſolution of them ſufficiently diluted is uſed for writing, the letters will be found to diſappear entirely, by the application of heat; and, if expoſed to the vapour of cauſtic volatile alkali, to change to a beautiful blue colour.

Thus, then, I have pointed out a method, as I apprehend, both eaſy and ſimple, by which all the known ſalts, about fifty in number, may be each denominated in one or at moſt in two words.—According to the firſt diviſion, we have the genus only.—Of the ſecond, the double ſalts completely ſaturated are indicated by the adjective of their baſe ending in *atus*. In the third, the imperfect ſalts are known by the genitive

genitive of their baſe.—The fourth contains the triple ſalts and thoſe of ſeveral principles, which are expreſſed by the trivial names; and as in them we neither find the adjective of the baſe *atus*, nor the genitive, it is not poſſible that any ambiguity can ariſe.—The whole compoſition of the triple ſalts could not be ſignified in two words, unleſs the double ſalts were defined in one only; and if the ſame brevity were expected of the quadruple, the triple muſt have neceſſarily been denominated by one. But it may be a queſtion, whether it is more difficult to invent ſuch a number of new and ſimple names, or, if invented, whether they could poſſibly be retained by the memory.

§ CXCVII. *Of the ſpecific Names of Earths, Metals, and Phlogiſtic Subſtances.*

If we conſider every thing that has been ſaid in the foregoing ſections on the ſubject of the ſalts hitherto known and inveſtigated, we ſhall find, that we have in ſome meaſure laid the foundation of a general ſyſtem of mineralogy. With regard to the earths, and the following claſſes, the denomination of the double and more compounded ſpecies may be conveniently expreſſed by the trivial names in two words. Thus, for example, under the genus magneſia, a ſpecies occur, in the formula, *ſmca*, compoſed of

of ſiliceous, calcareous, and argillaceous earth, with ſome admixture of iron *, which in ſyſtematic authors is denominated aſbeſtos, and treated as a peculiar genus. To this, indeed, the trivial name of aſbeſtos may be properly applied, as it ſeems to be ſo well underſtood, that the youngeſt mineralogiſt is in no danger of being miſled by it. The ſame may be ſaid of ſchoerl, granate, zeolite, and many others, that are diſtinguiſhed by names known to every body, and highly proper. In the compoſition of earths, iron is by no means a neceſſary ingredient, although it is generally found in them; and we therefore conſider it as an alloy, or heterogeneous ſubſtance.

§ CXCVIII. *Concluſion.*

I CANNOT finiſh my remarks on the denomination of foſſils more to my own ſatisfaction, than by pointing out what is yet wanting to the improvement of ſcience. I would wiſh that in the eſtabliſhing of new names, a preference ſhould be given to the Latin language. This is, or at leaſt was formerly the mother tongue of the learned; and being now not the living language of any nation, it is no longer liable to innovation or change. If therefore, the reform we propoſe is made firſt in Latin; it may be eaſily carried

* Diſſertation on the aſbeſtos.

carried into execution afterwards upon the ſame model in the modern languages, as far as their peculiar genius and conſtruction will admit.—In this manner, the language of chemiſtry will become every where uniform and conſiſtent, and conſiderable advantage will be derived not from the reading only of foreign publications, but the facility alſo with which they can be tranſlated. I have ſeen an excellent eſſay of Monſ. de Morveau on the reform of the French names*, and I am not a little flattered by the agreement I find between many of the alterations he propoſes and thoſe that I have offered on that ſubject. From this, perhaps, we may venture to hope, that by making it an object of further attention on both ſides, the differences yet ſubſiſting may be removed, to the great benefit of ſcience; and to the permanent eſtabliſhing and advancement of which all our views ſhould be directed.

* Diary of Monſ. Rozier.